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A REPORT ON THE PRODUCTION AND MARKETING FEASIBILITY OF THE FPL DEVELOPED PRESS-DRIED WALL PANELING AND FLOORING

John L. Walker

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by
John L. Walker
Associate Economist

United States Department of Agriculture
Forest Service
Northeastern Forest Experiment Station
Princeton, West Virginia

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Many persons in the wood-using industry provided essential background information for this study by showing me their plants and discussing their marketing channels and problems. These persons are far too numerous to mention, but a list of their companies is included in Appendix A.

Machinery and woodworking supply manufacturers provided a great deal of technical and price information. This often included complete line drawings of machine layouts prepared specifically for this study. Again, these persons are too numerous to mention individually, but their companies are listed in Appendix B.

The many building contractors, architects, and building supply dealers cannot be listed individually. Each, however, devoted a short time from their busy schedules to discuss my study and evaluate the paneling.

The opinions expressed and the conclusions reached in this study are, of course, those of the author alone. They are not necessarily shared by any of the individuals mentioned or referred to above. The author is also solely responsible for any errors or omissions found in this report.

INTRODUCTION

This report contains an analysis of the production and marketing feasibility of the press dried solid hardwood wall paneling and flooring developed by Bruce Heebink at the U.S. Forest Service's Forest Products Laboratory in Madison, Wisconsin. The Madison study report[1/] and the subsequent FPL publication[2/] were used as the basis for this feasibility study, but unpublished information obtained by more recent experiments at Madison and at the Wood Use Center of the University of Kentucky at Quicksand, Kentucky, were also used.

1/ Heebink, B. G. Utilization of low-quality small oak logs in paneling and flooring. (Unpublished FPL Study Report, U.S. Forest Serv., 45 pp., July 1965).

2/ Heebink, B. G. and Compton, K. C. Paneling and flooring from low-grade hardwood logs. U.S. Forest Serv. Res. Note FPL-0122, 23 pp., March 1966.

The Madison study gives a description of the products and their use along with some suggestions about the equipment that might be used for their commercial manufacture. The two most important machines mentioned were a sash gang saw for breaking down 100-inch long bolts, and a hot press for drying the green boards. The production cost analysis phase of this feasibility study centered around the use of these two machines, even though it soon became apparent that press drying would be more expensive than conventional kiln drying. Detailed cost projections were obtained for press drying because of the wide and favorable publicity it has been given in various trade journals as being an intregal part of the new products.

The data gathering for the feasibility study was divided into three distinct phases. The first phase involved visits to four firms presently producing solid hardwood paneling in Arkansas, Georgia, and Pennsylvania, and to three firms producing flooring in Tennessee. These firms were visited in order to observe and discuss their production methods and marketing channels.

The second phase was a market survey conducted in the metropolitan areas of Louisville, Kentucky; Pittsburgh, Pennsylvania; and Washington, D. C. It was designed to find out how acceptable the new products would be for various types of buildings and to get some indication of the volumes that might be sold at various price levels.

The last phase of this study was an estimation of production costs. A detailed layout was prepared of all the equipment that was judged the most suitable for the production of the paneling. This judgment was based on both the technical suitability of various makes and models of a machine and on their comparative prices. Descriptive literature and prices were obtained from usually two or more manufacturers for each item of standard equipment. Precontractural quotations and specifications were also obtained for machines that would have to be custom-made.

Production costs for the paneling were then computed by converting the present value of both the initial investment and operating costs to a level annual cost figure for a 25-year period, or the estimated economic life of the plant. This economic life was computed from the estimated cash flows using the criteria that if the plant were built, sales revenue must exceed operating expenses for continued operation.

SUMMARY AND CONCLUSIONS

The results of this feasibility study indicate that the new paneling and flooring products cannot be produced and marketed profitably. The products do have consumer appeal, but their estimated production and marketing costs are too high to result in competitive retail selling prices.

The two major reasons for these results are: (1) the low yield from the dried lumber and (2) the expense of advertising, selling, and distributing a specialty product. A new product with only one of these disadvantages might have a chance at success, but together they become almost insurmountable handicaps.

It should be stressed that the negative results of this study apply solely to the FPL paneling made from low-grade logs as specified by the Forest Products Laboratory using the processing equipment and methods described in this study. Substantial changes in the basic raw material, the product, processing technology, or in a combination of all three could result in positive results. Considerable effort was expended during this study, however, to come up with one of the better processing proposals currently available to a prospective manufacturer. Although there is admittedly room for improvement through detailed engineering studies, it is believed that changes in the raw material and/or final product offer the greatest chances for achieving an economically attractive proposal. Such changes would, of course, require corresponding changes in proposed production methods.

The physical plant for manufacturing these products as outlined in this study would require an initial investment of about $922,000. Preliminary studies for engineering, plant location, and market analysis would require another $30,000, while the working capital requirement would be an additional $347,000. A company wishing to build this plant would, therefore, need about $1,300,000.

This plant, including the sales and management personnel, would employ 54 persons with an annual payroll of $267,000. The operation would produce 3,200,000 square feet of paneling per year. Total production and selling costs before income tax considerations would average about $0.241 per square foot, if the cost of capital is assumed to be 6 percent. This cost is the weighted average of an estimated $0.252 per square foot for 2,500,000 square feet of prefinished paneling, and $0.202 per square foot for 700,000 square feet of unfinished paneling.

The selling and advertising costs were estimated for a company that already has a line of paneling and/or flooring on the market, and has a well-developed sales force and distribution system. Estimates of the costs a new company would incur to sell just this product are not included in this study, since preliminary calculations indicated that the establishment of a completely new sales force and distribution system, as well as a reputation for a quality product, would be prohibitively expensive.

The market survey results indicate that a company with a plant located in West Virginia, or in the adjacent areas of the surrounding states, could expect to sell its entire paneling production for an average of only $0.225 per square foot, f.o.b. the plant. At this price, it is estimated that the paneling could be sold in a 27-state area plus the southern portion of Ontario, Canada.

The market survey actually revealed a market for at least two grades of the paneling. One would consist of character-marked material which will subsequently be referred to as the paneling grade. The other, which will be called the flooring grade, would consist of clearer material that corresponds roughly to No. 2 Common and Better grades of oak flooring. This clearer grade could be used for either paneling or flooring, but it received a more favorable reaction as an accent flooring.

A breakdown of the weighted average sales price of $0.225 per square foot is shown in Table 1 along with the estimated production costs. Accessory products that would also be produced in the plant are shown with their prices figured at cost. These include matching mouldings which the market survey revealed would have to be provided by the company which made the paneling.

Table 1.--Estimated annual production, costs, and revenue before income tax considerations

Product	Annual production	Level annual cost	Cost per unit	Price per unit	Annual revenue
Unfinished paneling grade	200,000 sq. ft.	$ 40,400	$0.202	$0.150	$ 30,000
Prefinished paneling grade	1,000,000 sq. ft.	251,600	0.252	0.200	200,000
Unfinished flooring grade	500,000 sq. ft.	100,900	0.202	0.200	100,000
Prefinished flooring grade	1,500,000 sq. ft.	377,400	0.252	0.260	390,000
Matching mouldings	33,300 ln. ft.	5,000	0.150*	0.150*	5,000
Screened chips	2,500 tons	15,000	6.00	6.00	15,000
TOTALS		$791,300			$740,000

* Average figure for all types of mouldings

Parquet flooring is not included in Table 1 even though it was part of Heebink's new product proposal. No way was found to produce such flooring at a reasonable cost based on a scrap salvage operation. It was, therefore, dropped from the feasibility study without having its production costs analyzed in detail. It could possibly be made profitable by cutting entire boards into parquet slats. Such a process was beyond the scope of this study, even though at first glance it looks promising enough that it should perhaps be given further consideration. There are several similar types of parquet flooring already on the market and sufficient quantities are being sold so that it can almost be considered a commodity item. Their current f.o.b. mill prices are about $0.20 per square foot unfinished, and $0.25 per square foot prefinished.

Table 1 clearly shows that before income taxes are considered, a new plant for manufacturing the paneling would not be a profitable investment. In fact, its average losses would exceed $50,000 per year.

When the income tax advantages that could accrue to a large diversified corporation are considered, the uneconomic features of these new products are not nearly as apparent. A corporation with sufficient credit to borrow the entire amount needed for a new plant, that also has net earnings which place it well into the maximum corporation tax bracket of 48 percent, would achieve the lowest after-tax production costs of $0.229 per square foot. Since these average

cost estimates are still higher than the average expected sales price, it is very unlikely that even a large corporation would decide to manufacture the new paneling and flooring. Most of the largest corporations in the forest products industries own and operate their own wholesale distribution centers and could expect to make their normal distribution profits. Whether or not these profits would be sufficient to offset an unprofitable manufacturing operation would have to be decided by these companies.

The small number of large diversified wood using corporations with their own wholesale distribution centers is further reduced when just those with manufacturing operations and land holdings in the central Appalachians are considered. None of these corporations have undertaken secondary product manufacture in this area either. It is extremely doubtful that any of them can be induced to undertake such an operation in Appalachia simply because it will utilize low-grade hardwoods and employ a few people. Such a decision would have to result from the prospect of improving their profits (perhaps by minimizing some losses) by diverting their low-grade logs from existing sawmill operations to an FPL paneling plant.

Undoubtedly, a company that decided to actually build a plant for the FPL paneling could reduce the required investment somewhat. It could purchase some used instead of all new equipment. Also some types of equipment could be changed. The major savings could be made by using kilns instead of a press for drying the wood. This

would reduce production costs perhaps as much as $0.01 per square foot. This might make the product financially feasible for a large corporation that could benefit from all possible income tax advantages, but it would not provide any appreciable profit margin. For a company that could obtain no appreciable tax advantages, all drying costs would have to be eliminated to make manufacturing the FPL paneling a financially feasible operation. The question of kilns versus a press for drying the wood is therefore not a very significant factor. The results of this study are so conclusively negative that it is very unlikely that production costs can be reduced enough to make an FPL paneling plant an attractive investment.

This feasibility study has pointed out, however, that there is still room in the paneling and flooring markets for new products. The market survey shows that people would be receptive to a solid wood paneling as well as another flooring product. This conclusion supports a similar finding in another study,[3/] and it is still believed that solid wood paneling of a different sort may be a profitable diversification for established wood-using companies producing such items as flooring, plywood paneling, cabinets, or trim.

3/ Smith, R. C., Paulsell, L, K., and Leney, L. Oak paneling--its processing and marketing. Univ. of Mo. Agr. Expt. Sta. Bul. 737, 32 pp., July 1959.

This study may also provide a guide to prospective manufacturers of similar new products and to researchers working on new product development. It contains estimates of what the markets will absorb and of what the production costs for various processing steps might be. It is hoped that these results can be applied to similar new product and marketing proposals. The assumptions used in this study have been made very explicit to facilitate such an application.

MARKET POTENTIAL

MARKET SURVEY PROCEDURES

The market potential of the FPL paneling was determined by market surveys in the metropolitan areas of Louisville, Kentucky; Pittsburgh, Pennsylvania; and Washington, D. C. These cities were chosen as survey cities because of their proximity to the Appalachian area in which it was hoped the new products would be manufactured, and because they had wholesale distributors for both of the companies known to produce and sell solid hardwood wall paneling as a major and standard item. They were also chosen because each was in a separate geographical area, and this would help to eliminate, or at least reveal, any geographical bias in decorating tastes.

A total of 54 homebuilding or remodeling contractors, 23 architects, and 14 building supply dealers were contacted during these market surveys. The names of the builders and architects were obtained from the local chapters of the Home Builders Association and the American Institute of Architects. The contractors and building suppliers were concerned primarily with residential construction. The architects, however, worked on a fairly large variety of building types including subdivision homes, custom designed homes, schools, office buildings, churches, restaurants, and recreation lodges. Each architect specialized in just one or few types of these buildings. Only architects who used appreciable amounts of wood in their designs were included in the surveys.

Originally, it was intended that homeowners would be contacted during the market survey to get their reactions to the new paneling. The building contractors, however, said that home buyers generally have very little to say about the type of paneling that goes into a home. Even in the better custom-built homes, they are usually just given a choice of several different species or colors from the company's line carried by the contractor. Very seldom does a home buyer ask to compare this line of paneling with other brands or types of paneling on the market. They usually make their choice of paneling as the house nears completion and they can better visualize how it will look. When a contractor gets a contract to build a house, paneling is not usually discussed. The builders, therefore, play the dominant role in deciding what type of paneling will generally be used in their homes, even in the most expensive subdivisions where very few homes are built speculatively. They narrow down the alternatives available to the home buyer to just a few before presenting him with a choice. Most builders also said that home buyers would have no idea what various types of paneling materials cost or what their installation costs would be.

Even in the expensive custom-designed homes, architects usually perform the same function as the builders do for subdivision homes as far as the choice of paneling is concerned. They select one or perhaps a few types of paneling for their client's approval or choice. The influence of the architects and builders on the choice

of paneling found during this study contrasts sharply with another recent study by Huber, Lindell, and Swinyard.[4/] Their study credits home buyers with a major role in the choice of paneling. It was based on interviews with new homeowners, however, who probably were not aware of the extent that their actual choice may have been limited by the preselection of the builders and architects. Nevertheless, homeowners were excluded from this study.

For the market surveys, color photographs were taken of a mock-up wall using various furniture arrangements to show how the paneling would look when installed horizontally. Four 2- by 4-foot displays of the actual paneling were also prepared to show how it would look and how the various sizes would be installed.

Two of the displays were red oak finished with only a clear sealer. These two displays were graded so that one contained character-marked paneling and the other only clearer material of the flooring grade. The other two displays were ungraded red oak stained walnut and cherry prior to a clear sealer finish.

Two of the parquet flooring blocks and some individual pieces of the paneling, 16-inches long and 2-, 3-, 4-, and 6-inches wide, were also used as survey samples.

4/ Huber, H. A., Lindell, G., and Swinyard, A. W. Homeowners' attitudes on wood paneling. Forest Prod. Jour., pp. 71-75, September 1966.

A questionnaire was not used for the surveys. The new paneling and flooring products were shown and explained to each person. This was followed by an informal discussion regarding the products and how they would fit into their existing work. A record of each discussion was written up immediately after it was concluded. These records are on file at the Forest Products Marketing Laboratory.

The surveys would have been extended to one or more additional cities except that a pattern emerged from just these three which was deemed adequate for estimating the demand for the new products in new residential construction. This pattern was used as a guide for estimating the volumes that could be sold in other cities as well. This was done by relying on estimates of new housing starts and their price distribution for each city. These estimates were obtained from the U.S. Bureau of the Census' Construction Reports and from the housing market analysis that the Federal Housing Administration has made for over 70 metropolitan areas.

Equally good data were not available for estimating the size of the market for home remodeling and recreation developments such as rural motels and lodges, restaurants, and cabins; but the information obtained during the market survey supports the belief that these markets, when taken together, are at least twice as large as the new home construction market.

MARKET SURVEY RESULTS

The overall reaction to the FPL paneling, as paneling, was that it would generally be preferred to plywood paneling selling for a retail price of $10 to $12 or less per sheet (32 square feet). The people using these lower grades of plywood paneling, however, are not willing to pay any more. There are already better grades of paneling on the market that they could use if they thought they could afford to pay more.

The reactions to the new paneling were mixed when it was compared with plywood paneling selling for more than $12 per sheet. Some persons expressed a preference for it; others did not. In this higher price range, the new paneling would have to compete not only with the better grades of plywood paneling, but also with such species as walnut, cherry, and pecan--which are now very popular. Price is still an important consideration, but this higher priced paneling is used predominately in the highest priced subdivision and custom-designed homes where species, quality, style and appearance are also important factors affecting the choice of paneling.

These subdivision homes are usually custom-built and range upwards in price from $25,000 to $35,000 depending on the metropolitan area in which they are built. On the average, they comprise only 5 to 10 percent of all new homes built in metropolitan areas, although the percentage may occasionally be as high as 20 or as low as 1 or 2. This is the new residential construction market, however, in

which the FPL paneling would have to be sold because its costs of production preclude it from the lower priced, but much larger, housing markets. The amount of the FPL paneling that could be sold even in this market would be very sensitive to its price because of the large number of substitute paneling products available and the cost consciousness of the builders.

In the remodeling market, the price range of the homes in which the FPL paneling would be used is much wider than in the new construction market. Homeowners contemplating a small remodeling project are not nearly as cost conscious as new homebuilders. Remodeling contractors also have more incentive to try to upgrade a customer's choice of paneling since they normally get a higher mark-up than new homebuilders do on such items.

Most of the contractors did not think the new paneling would cost much more to install than the plywood sheets. The individual pieces would go up slower than plywood on large expanses of wall, but faster on areas where they would have to be fitted around windows and doors. The individual pieces would not require the planning and careful trimming and fitting needed for plywood sheets. With the solid wood paneling, there would also be no nails to countersink and no holes to fill. Waste would also be negligible for the new paneling regardless of a wall's size or shape, whereas with plywood panels, there are usually fairly large pieces that cannot be used after the sheet has been cut to fit.

The do-it-yourself remodeling market does not appear to be well-suited for a higher priced paneling. None of the building supply dealers catering to do-it-yourselfers thought the FPL paneling would sell well enough that they would stock it, unless they could sell it for no more than $0.25 to $0.30 per square foot. For example, one dealer located near nice residential areas in the Pittsburgh suburbs said that he sells mostly "junk" paneling and that about 75 percent of his sales are for sheets under $7. His highest priced sheet is a medium grade walnut panel that sells for $15 but it is a very slow mover.

The FPL paneling is designed for either horizontal or vertical installation, but most people said they would not try a horizontal installation. They were accustomed to vertically installed paneling and felt that it looked better that way. Several also thought that horizontal paneling would make the ceiling look too low. The preference for vertical paneling was particularly strong in the Washington, D. C. area. Not one of the persons contacted in this area thought that a horizontal installation would be acceptable because of the strong traditional influences on local decorating tastes.

The survey also revealed that in higher priced homes, the new paneling would generally be acceptable only for informal areas such as family rooms or dens. The informal appearance of the paneling is due to the random arrangement of the boards. The character-marked material seemed to complement the informal board arrangement since

it was generally preferred to the clearer material. It would be used primarily as an accent material on only one or two walls in a room instead of on all four walls.

Several architects said they could use something like the FPL paneling. The ones who preferred it most would use it in recreation lodges and cabins. Other architects, who designed buildings such as churches, thought the new paneling would be too informal for most of their work. Most of the architects who liked the FPL paneling s aid they could probably use it in only one building every 1 or 2 years. Each building requires something different and special milling patterns and board arrangements are normally written into the specifications. For any appreciable use by architects, the new paneling would have to be given a well-advertised brand name that could be written into the specifications for each building in which an architect wished to use it.

No one objected to the stained material, and many preferred it it the naturally finished oak. This would make staining a good way to provide color variety without using the more expensive woods. Another advantage from staining is that character-marks which stand out too vividly on naturally finished wood are not nearly as apparent and can become attractive when stained.

The FPL paneling received a more favorable reaction as flooring than it did as paneling. This was due to the fewer accent flooring substitutes available, and because at any given price, the new product

would compete better with flooring than it would with paneling. Many custom builders who are paying about $1.00 per square foot for installed accent flooring pay only $0.40 to $0.60 for installed paneling in the same room. Also, as flooring, the new product would be used in lower priced homes and would, therefore, have a much larger market than if used only as paneling.

The wider boards available in the new product help make it attractive as a flooring material. If properly spaced, they give the illusion of the colonial plank-type floors which are too expensive for most homes. Many builders said the new product would be just as attractive as any of the simulated plank floors now on the market and would be willing to buy it at a competitive price. The builders in the Washington, D. C., area would be particularly willing to use it in their competition townhouses. Several builders were a bit skeptical about the stability of the wider boards, however. They would have to be assured and then find out through experience, that these boards would not cause any warping or squeaking problems before the new product would be widely accepted.

Like the character-marked or paneling grade, the flooring grade would be used primarily as an accent material in informal areas. It would require more careful packaging than the paneling grade, however, so that only desirable joints would occur when it is installed. This will be discussed later in the production methods section when the packaging procedures are outlined.

Stained flooring would be readily accepted and fewer colors would be needed for it than for the paneling grade.

Based on the information obtained in the market surveys, it is believed that an average f.o.b. plant price of $0.225 per square foot or lower would be needed to result in competitive enough retail prices to sell all the FPL paneling produced by the plant described in the production methods section of this report. This average price would be the weighted average of $0.15 per square foot for 200,000 square feet of the unfinished paneling grade, $0.20 per square foot for 1,000,000 square feet of the prefinished paneling grade and 500,000 square feet of the unfinished flooring grade, and $0.26 per square foot for 1,500,000 square feet of the prefinished flooring grade.

Table 2 shows the cash flow estimates for the FPL paneling plant's sale revenue. It shows that once the plant and selling operations reach their normal levels, sales revenues would average $740,000 per year. This includes $720,000 for both grades of paneling, $5,000 for matching mouldings, and $15,000 for screened chips. The present value of all this sales revenue is $8,783,000 when discounted at a 6 percent rate of interest. The method used to compute this present value is identical to that used to compute the present values of the production costs. It is described in detail at the beginning of the production cost section.

Table 2.--Sales revenue cash flow estimates for the FPL paneling plant

Year (t)	FPL paneling	Matching mouldings	Screened chips	Total sales revenue
0	$ 000	$ 000	$ 000	$ 000
0.5	000	000	000	000
1	000	000	000	000
1.5	180,000	1,200	3,800	185,000
2	360,000	2,500	7,500	370,000
3 - 26	720,000/yr.	5,000/yr.	15,000/yr.	740,000/yr.
27	90,000	600	000	90,600
Present value at 6 percent interest	$8,546,000	$59,300	$177,700	$8,783,000

GEOGRAPHIC DISTRIBUTION OF POTENTIAL SALES

In order to sell all of the FPL paneling at the f.o.b. plant prices discussed previously, it would have to be distributed in at least 27 states plus the southern portion of Ontario, Canada. This is assuming that the plant would be located in West Virginia or in an adjacent area of a neighboring state. The average retail prices throughout this market region would be about double the f.o.b. plant prices due to transportation charges and wholesale and retail markups. To market the paneling in a smaller region would require even lower f.o.b. plant prices.

Table 3 shows how potential FPL paneling sales would be distributed throughout the estimated market region. Each city listed designates a Standard Metropolitan Statistical Area as defined by the Bureau of the Budget in 1964. Only the primary city in each area is used for the designations, and they are listed alphabetically under the state in which this city is located. The sales forecasts for several of these metropolitan areas include sales in more than one state since the areas include sections in more than one state. The forecast given for each metropolitan area includes all types and grades of the FPL paneling that could be sold within the area and within adjacent rural areas. Standard Metropolitan Statistical Areas with estimated annual sales of less than 1,000 square feet, have been excluded since no dealer would be interested in handling such a small volume.

Table 3.--Annual FPL paneling sales forecast by standard metropolitan statistical areas

(Based on a $0.225 average f.o.b plant price per square foot)

Standard metropolitan statistical area	Annual sales forecast (sq. ft.)
Columbia, District of Washington	320,000
CONNECTICUT	200,000
Bridgeport	27,000
Hartford	70,000
Meriden	5,000
New Britain	9,000
New Haven	14,000
New London	7,000
Norwalk	9,000
Stamford	43,000
Waterbury	16,000
DELAWARE	25,000
Wilmington	25,000
GEORGIA	40,000
Atlanta	40,000
ILLINOIS	530,000
Champaign	6,000
Chicago	480,000
Decatur	1,000
Peoria	22,000
Rockford	14,000
Springfield	7,000
INDIANA	110,000
Anderson	9,000
Evansville	5,000
Fort Wayne	13,000
Gary	36,000
Indianapolis	37,000
Muncie	2,000
South Bend	7,000
Terre Haute	1,000

Table 3 -- Continued

Standard metropolitan statistical area	Annual sales forecast (sq. ft.)
IOWA	20,000
Cedar Rapids	6,000
Davenport	7,000
Des Moines	5,000
Dubuque	1,000
Sioux City	1,000
KANSAS	4,000
Topeka	2,000
Wichita	2,000
KENTUCKY	20,000
Lexington	7,000
Louisville	13,000
MAINE	5,000
Portland	5,000
MARYLAND	130,000
Baltimore	130,000
MASSACHUSETTS	220,000
Boston	125,000
Brockton	20,000
Fall River	4,000
Fitchburg	4,000
Lawrence	12,000
Lowell	21,000
New Bedford	7,000
Pittsfield	2,000
Springfield	10,000
Worcester	15,000
MINNESOTA	70,000
Minneapolis	70,000

Table 3 -- Continued

Standard metropolitan statistical area	Annual sales forecast (sq. ft.)
MISSOURI	60,000
Kansas City	20,000
Springfield	2,000
St. Joseph	1,000
St. Louis	37,000
NEBRASKA	10,000
Lincoln	4,000
Omaha	6,000
NEW HAMPSHIRE	1,000
Manchester	1,000
NEW JERSEY	150,000
Atlantic City	4,000
Jersey City	4,000
Newark	90,000
Paterson	40,000
Trenton	12,000
NEW YORK	350,000
Albany	20,000
Binghamton	8,000
Buffalo	35,000
New York	225,000
Rochester	40,000
Syracuse	18,000
Utica	4,000
NORTH CAROLINA	30,000
Asheville	2,000
Charlotte	4,000
Durham	5,000
Greensboro	6,000
Raleigh	5,000
Winston Salem	8,000
OHIO	250,000
Akron	25,000
Canton	7,000

Table 3 -- Continued

Standard metropolitan statistical areas	Annual sales forecast (sq. ft.)
OHIO (Continued)	
Cincinnati	35,000
Cleveland	56,000
Columbus	36,000
Dayton	35,000
Hamilton	7,000
Lima	3,000
Lorain	9,000
Springfield	4,000
Steubenville	3,000
Toledo	20,000
Youngstown	10,000
PENNSYLVANIA	330,000
Allentown	15,000
Altoona	2,000
Erie	4,000
Harrisburg	5,000
Johnstown	3,000
Lancaster	5,000
Philadelphia	200,000
Pittsburgh	80,000
Reading	4,000
Scranton	1,000
Wilkes-Barre	2,000
York	9,000
RHODE ISLAND	60,000
Providence	60,000
SOUTH CAROLINA	5,000
Charleston	3,000
Columbia	1,000
Greenville	1,000
TENNESSEE	20,000
Chattanooga	2,000
Knoxville	5,000
Nashville	5,000
Memphis	8,000

Table 3 -- Continued

Standard metropolitan statistical area	Annual sales forecast (sq. ft.)
VIRGINIA	90,000
Lynchburg	5,000
Newport News	20,000
Norfolk	32,000
Richmond	25,000
Roanoke	8,000
WEST VIRGINIA	10,000
Charleston	4,000
Huntington	4,000
Wheeling	2,000
WISCONSIN	80,000
Green Bay	2,000
Kenosha	7,000
Madison	17,000
Milwaukee	40,000
Racine	14,000
ONTARIO, CANADA	60,000
Brantford	3,000
Hamilton	8,000
Kitchner	4,000
London	6,000
Sarnia	1,000
Toronto	30,000
Windsor	8,000
TOTAL ANNUAL SALES FORECAST	3,200,000

The main purpose of Table 3 is not to accurately predict possible annual sales for each metropolitan area. The volumes that would be sold in any one area would fluctuate considerably from year to year. Also the data on which these estimates are based are not good enough for real accurate estimates. The forecasts have been made in such detail primarily to illustrate the distribution and sales problems that would be encountered in merchandising the FPL paneling. This is why the selling and advertising cost estimate amounts to more than 24 percent of the total manufacturing costs for this product. The small volumes shown for the smaller metropolitan areas also indicate that this product could not be sold at all in these areas unless it was added to an existing product line. No salesman or dealer would be interested in such a small total volume of sales from one product line.

About 50 wholesale distributors would be needed to stock and deliver the FPL paneling. Very few retail dealers would want to carry the paneling in stock. Most of the retailers would maintain a display, take orders, and then have the paneling delivered either to them or directly to the customer.

In order for both wholesalers and retailers to be interested in handling a product like the FPL paneling, they would also normally have to be servicing market areas that had one or more competing dealers. Otherwise, FPL paneling sales would just reduce their sales of other paneling and flooring products by a like amount.

Competing dealers would be needed to absorb some of the decreased sales in competing products in order for the FPL paneling dealers to achieve a net gain in overall sales.

PRODUCTION METHODS

GENERAL

Before production costs for the proposed paneling could be estimated with any degree of accuracy, it was necessary to get a fairly specific idea of the amount of material that would be processed by a given set of equipment. The plant scale used in this analysis was determined by the estimated gang saw production with the remaining equipment chosen accordingly. It was assumed that rational plant management would operate the gang saw at least one full shift per day.

The needed press drying capacity was determined by the estimated daily output of edged boards from the sawmill. Three alternatives were considered. The first was to include sufficient press drying equipment to dry the boards during the same shift they were produced. The other two alternatives were to dry one shift's board production during either two or three drying shifts, with temporary storage facilities for the boards that could not be dried during the first shift. Due to the cost of pressing equipment, a three-shift drying operation was chosen. This would not permit much latitude for expanding plant production since additional drying capacity would have to be installed for the entire plant to operate more than one shift per day. The market survey portion of this study indicated, however, that the paneling generated by more than a one-shift sawmill operation probably could not be sold for anything near what it would cost to produce.

The plant layout shown in Figure 1 was developed using the previously mentioned assumptions regarding the sash gang saw and press drying equipment. It shows the building, all the processing equipment and material handling systems used for estimating the initial investment and production costs for the new paneling. The daily material flow assumptions used for determining the capacity requirements for each machine included in this layout are shown in Table 4.

This plant can logically be divided into eight departments. These are the office, sawmill, drying, woodworking, prefinishing, packaging and warehousing, general maintenance, and sales and advertising. The production processes assumed for each of the five manufacturing departments are discussed in detail in the following section so that the major assumptions behind the production cost estimates can be understood and compared with other processing methods and costs.

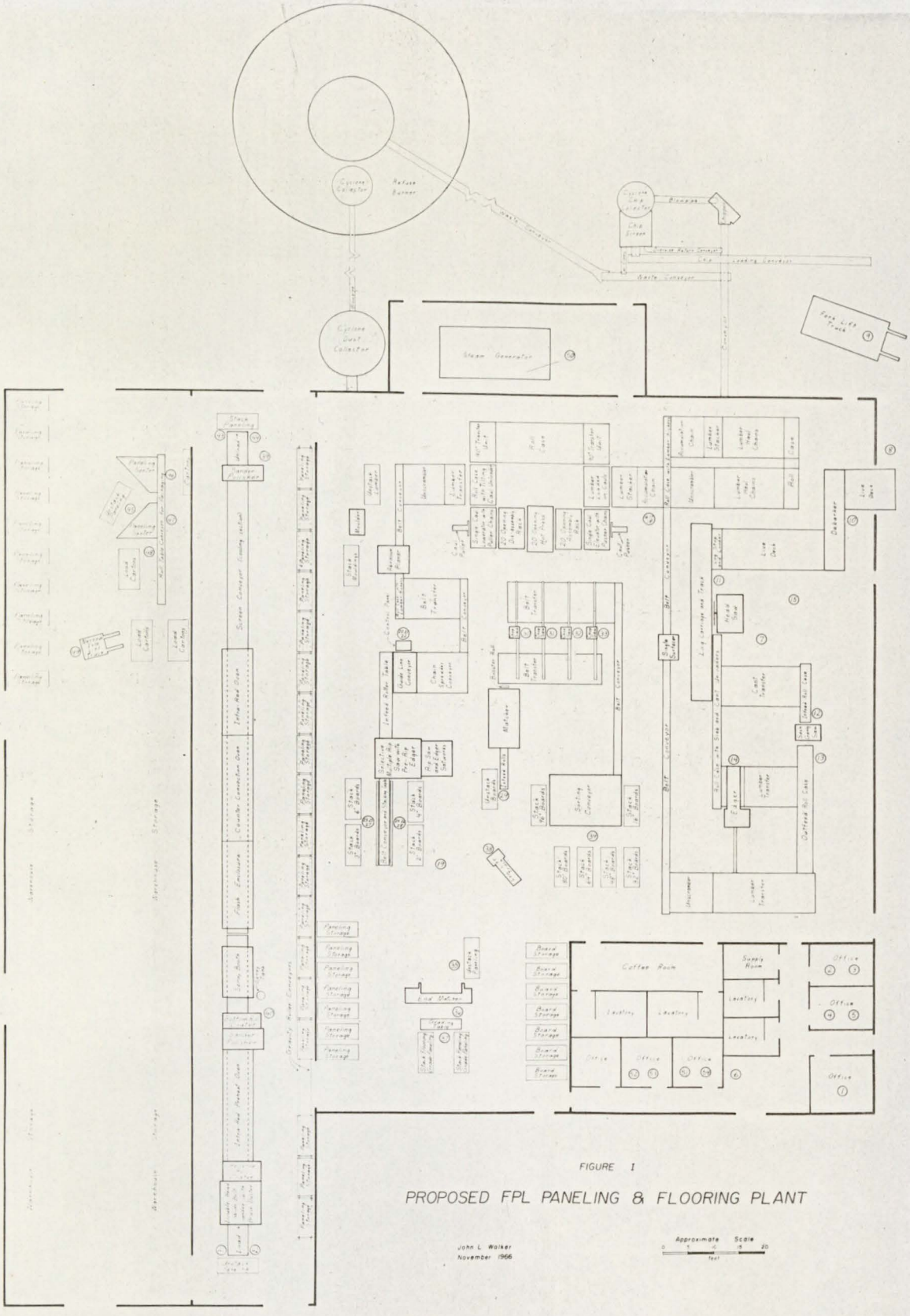

FIGURE 1

PROPOSED FPL PANELING & FLOORING PLANT

John L. Walker
November 1966

Approximate Scale
0 5 10 20
feet

Table 4.--Daily material flow assumptions for the FPL paneling plant

(ratios may not be consistent due to rounding)

Processing machine	Input	Output	Residue	
			Form	Amount
Debarker	330 logs	330 logs	--	--
	*10,000 bd. ft.	*10,000 bd. ft.	--	--
	2,300 cu. ft.	1,980 cu. ft.	bark	**320 cu. ft.
	140,000 lbs.	127,800 lbs.	bark	12,200 lbs.
Circular head saw	330 logs	330 logs	--	--
	*10,000 bd. ft.	20,000 bd. ft.	--	--
	1,980 cu. ft.	1,720 cu. ft.	sawdust	** 20 cu. ft.
			slabs	240 cu. ft.
	127,800 lbs.	110,700 lbs.	sawdust	1,200 lbs.
			slabs	15,900 lbs.
Sash gang saw	330 cants	5,000 boards	--	--
	20,000 bd. ft.	32,000 sq. ft.	--	--
	1,720 cu. ft.	1,390 cu. ft.	sawdust	**280 cu. ft.
			slabs	50 cu. ft.
	110,700 lbs.	89,500 lbs.	sawdust	18,000 lbs.
			slabs	3,200 lbs.
Edger	32,000 sq. ft.	30,000 sq. ft.	sawdust	220 sq. ft.
			edgings	1,780 sq. ft.
	1,390 cu. ft.	1,300 cu. ft.	sawdust	** 10 cu. ft.
			edgings	80 cu. ft.
	89,500 lbs.	84,000 lbs.	sawdust	600 lbs.
			edgings	4,900 lbs.

Table 4 -- Continued

Processing machine	Input	Output	Residue	
			Form	Amount
Single surfacer	30,000 sq. ft.	30,000 sq. ft.	--	--
	1,300 cu. ft.	1,240 cu. ft.	chips	** 60 cu. ft.
	84,000 lbs.	79,200 lbs.	chips	4,800 lbs.
Press dryer	30,000 sq. ft.	29,500 sq. ft.	--	--
	1,240 cu. ft.	1,050 cu. ft.	--	--
	79,200 lbs.	44,400 lbs.	water(steam)	34,800 lbs.
Abrasive planer	29,500 sq. ft.	29,500 sq. ft.	--	--
	1,050 cu. ft.	925 cu. ft.	dust	**125 cu. ft.
	44,400 lbs.	39,200 lbs.	dust	5,200 lbs.
Selective multiple ripsaw	29,500 sq. ft.	27,500 sq. ft.	sawdust	**200 sq. ft.
			chips	**800 sq. ft.
			scrap	1,000 sq. ft.
	925 cu. ft.	860 cu. ft.	sawdust	** 6 cu. ft.
			chips	** 26 cu. ft.
			scrap	33 cu. ft.
	39,200 lbs.	36,600 lbs.	sawdust	260 lbs.
			chips	1,040 lbs.
			scrap	1,300 lbs.
Matcher	27,500 sq. ft.	24,200 sq. ft.	chips	**3,300 sq.ft.
	860 cu. ft.	755 cu. ft.	chips	** 105 cu. ft.
	36,600 lbs.	32,200 lbs.	chips	4,400 lbs.

Table 4 -- Continued

Processing machine	Input	Output	Residue	
			Form	Amount
Chop saws	24,200 sq. ft.	14,000 sq. ft.	sawdust	**100 sq. ft.
			scrap	10,100 sq. ft.
	755 cu. ft.	445 cu. ft.	sawdust	** 3 cu. ft.
			scrap	307 cu. ft.
	32,200 lbs.	18,700 lbs.	sawdust	125 lbs.
			scrap	13,375 lbs.
Double-end matcher	14,000 sq. ft.	13,100 sq. ft.	chips	**900 sq. ft.
	445 cu. ft.	416 cu. ft.	chips	** 29 cu. ft.
	18,700 lbs.	17,600 lbs.	chips	1,100 lbs.
Wide belt sander	13,100 sq. ft.	13,100 sq. ft.	--	--
	416 cu. ft.	410 cu. ft.	dust	** 6 cu. ft.
	17,600 lbs.	17,400 lbs.	dust	200 lbs.
Finishing line	13,100 sq. ft.	13,100 sq. ft.	--	--
	410 cu. ft.	410 cu. ft.	--	--
	17,400 lbs.	17,500 lbs.	dust	100 lbs.
Final inspection	13,100 sq. ft.	12,800 sq. ft.	boards	300 sq. ft.
	410 cu. ft.	400 cu. ft.	boards	10 cu. ft.
	17,500 lbs.	17,000 lbs.	boards	500 lbs.
Packaging	12,800 sq. ft.	400 cartons	--	--
	400 cu. ft.	600 cu. ft.	--	--
	17,000 lbs.	20,000 lbs.	--	--

* Doyle log scale
** Solid wood equivalent

SAWMILLING

The sawmill department shown in the plant layout includes a forklift truck, a debarker, a circular head saw and carriage, a sash gang saw, an edger, chipping equipment, and all the accessory conveyors and waste disposal equipment.

This department would employ seven full-time men plus a foreman and a saw filer. The foreman would spend about 60 percent of his time in this department and about 40 percent in the drying department. The saw filer's time would be about equally divided between the sawmill and the woodworking departments. One of the men would spend his full time procuring bolts for the mill. The remaining six men would operate machinery.

A forklift truck with tilting forks, a forward reach, and a log baling attachment would be used for unloading delivered bolts, yard handling, and for feeding the live deck leading to the debarker. A machine with a rated capacity of 6,000 pounds would be adequate for this job. All bolts would be about 100 inches long and exceed 8 inches in diameter.

A debarker was included in the layout primarily to provide bark-free slabs and edgings for the chipper. The clean bolts would also favorably affect lumber production and saw maintenance. If, however, the plant was located where it did not have a good chip market and no chipping system was included, the debarker would not be justified for

just cleaning the bolts. The slabs and edgings would burn better with the bark on them, and the cost of a debarker and its operator would exceed the reduction in saw maintenance costs and the value of increased lumber production.

The small carriage and circular head saw are included in the layout to slab one or two sides of each bolt prior to gang sawing. A log gang layout was discarded after considerable thought because of the problems that would be encountered. Under normal conditions, a cant gang layout will increase production 5 to 10 percent and minimize the amount of miscut lumber. The thin board requirements for this paneling would accentuate the problems normally encountered with just a log gang operation. There is no outfeed holding device that will work satisfactorily when so much of the log is removed as saw kerf. Also, the rough bolts would have a tendency to twist in the gang saw after they were released by a log gang carriage.

The circular saw could also be used to cut the 1-inch and thicker lumber that would be needed for matching moulding. This lumber would have to be press dried in the plant if it is to match the paneling. It can be specially quarter-sawn on the circular saw if necessary, to facilitate press drying.

One man is all that would be needed for the circular saw and related equipment. He should have ample time to prepare a log for the gang saw every 1- to -2 minutes using a live deck, a hydraulic log turner with a stop and loader, a hydraulic carriage with power

dogs and setworks, a powered tailing device fitted on the saw husk, and a live main roll case with a 2-chain air-lift cant transfer and a 2-arm slab unloader.

The sash gang saw would require a man on both the infeed and outfeed sides. The infeed man would keep the cants feeding butt to butt. The outfeed man would sort out the wane-edged material and send it to the edger.

The feed speeds assumed for this operation have determined the scale of the entire plant (Table 5). They vary from 4 feet per minute for a 14-inch cant to 10 feet per minute for an 8-inch cant. Logs larger than 14 inches, d.i.b., would have to be sawn down to this size because the maximum number of saw blades that can be put into the gang saw is 22. It is assumed that the boards would be sawn to a green thickness of $.530^{+}_{-}$ .030 inches.

Table 5.--Sash gang saw feed speed estimates

D.i.b. (inches)	Feed speed	Sawing time (minutes)
8	10	.80
9	9	.89
10	8	1.00
11	7	1.14
12	6	1.32
13	5	1.60
14	4	2.00

The wane edged boards would be edged in order to fully utilize the drying area in the press dryer. Edged boards from both the gang saw and the edger would be conveyed to a chain lumber transfer which would take them to an unscrambling conveyor. The boards would then be fed one at a time to the drying department.

The chipping system shown on the layout includes a small horizontal chipper, cyclone collector, chip screen and conveyors. Chippable residue from the sawmill should yield about 10 tons per day. This is a marginal quantity and the desirability of including chip production in this plant would be dependent upon a good chip market.

PRESS DRYING

The press drying department shown on the layout contains a 20-opening hot press, loading and unloading devices, a caul circulating system, a special lumber handling and storing system for the lumber that would be dried during the second and third shifts, and special surfacing equipment. The surfacing equipment is included in the drying department so that the drying cost estimates can be compared to kiln drying costs for thin lumber. The press is designed to dry 1/2-inch boards in 35 minutes using a platen temperature of 350° F. and 50 p.s.i.

Lumber leaving the sawmill department would be fed one board at a time through a high speed single surfacer to obtain a more uniform thickness of $.500^{+}_{-}$ .005 inches.

Two-thirds of the lumber would then go to the lumber handling and storage system where it would be automatically tight-stacked and stored on haul chains.

One-third of the lumber would be diverted to an accumulation chain and lumber stacker which would automatically assemble and place it on cauls. Each caul would be 102- by 60-inches and would hold about 40 square feet of lumber.

A man stationed by the accumulation chain would see that the random width boards are assembled as efficiently as possible before they are placed on the cauls. For example, if boards totaling 54 inches have accumulated and the next board was 12-inches wide, the man would wait for and then manually replace it with a board 6-inches or less in width. Otherwise, 4 square feet of the caul's capacity would be wasted during the next press drying cycle. This job alone would probably not warrant a man, but someone would be needed to monitor the press drying equipment. One man on each shift could perform both functions with no other direct labor required. The sawmill foreman could also be in charge of this department and this would require about 40 percent of his time. All the machinery, however, would operate automatically.

As soon as a caul is loaded with lumber, it would be advanced by a 2-chain conveyor into a caul elevator that would lift it to the desired height where it would be conveyed into a stationary assembly rack by pusher chains. The elevator would then descend to receive

the next caul. Each trip of the elevator would go to a different level of the assembly rack until all 20 openings are filled. This loading system would be much simplier and less expensive than the standard type of hydraulic loading units normally used for multiple opening laminating presses. A drying cycle would be much longer than a laminating cycle, so there would be ample time for simple chain conveyors to move each caul individually from where it is loaded with lumber to a slot in a stationary assembly rack. The average time available for moving each caul would be almost 2 minutes.

When the press opens at the end of a drying cycle, a caul pusher would push all the cauls assembled in the rack into the press at one time. A caul puller would simultaneously pull the cauls loaded with dried lumber out of the press into a disassembly rack and the press would automatically close for another drying cycle. A caul lowerator with puller chains would then remove the cauls from the disassembly rack one at a time in a process just reversing that used to load the assembly rack.

As a caul is lowered to the regular working level, it would be picked from the lowerator chains by powered rollers and conveyed to the lumber unloading station. Arms of a tilting unit would then pick it up and tilt it to an angle which would allow the boards to slide off onto a lumber transfer. The caul would then be lowered back onto the powered rollers and continue around the caul circulation system to the lumber loading station where the cycle would begin again.

The press drying cycle for the lumber would take 37- to 38-minutes assuming that the actual time required for drying the .500-inch thick lumber is 35 minutes. This time was given to me during a telephone conversation with Bruce Heebink. It was based on experiments completed after his original study which found that 50 minutes would be required to adequately dry .6-inch thick red oak to an average moisture content of 8 percent. The .1 inch reduction in thickness apparently reduces the drying time by 15 minutes, but it also makes special surfacing equipment needed for achieving this thickness accurately prior to drying and for surfacing and accurately dimensioning the boards after they are dried. This special surfacing equipment includes the high speed single surfacer already mentioned and an abrasive planer. Neither of these machines would require an operator and they would cost less than additional press capacity to compensate for a 50-minute drying time.

After the boards have been tilted off the cauls onto a lumber transfer, they would be conveyed by an unscrambler and accumulation chain to the infeed conveyor for the abrasive planer. They would then be fed one board at a time onto this conveyor and through the planer.

An abrasive planer with two opposed 18-inch wide heads would remove equal amounts of stock from both sides of each board. Unpublished experiments at Madison indicate that this equal stock removal from both sides of the board would be needed to prevent

severe cupping problems. An abrasive planer has been specified for this process because the stock would emerge from the press so thin that a conventional knife planer would not do a satisfactory job of cleaning them up to the desired thickness. Red oak boards put into the press at $.500^{+}_{-}$ .005 inches would emerge $.430^{+}_{-}$ .030 inches thick. The planer would then reduce this to $.380^{+}_{-}$ .003 inches.

Although this planer is included in the drying department to make the estimated drying costs more comparable to kiln costs for thin lumber, it would also favorably affect the woodworking operations. Surfacing prior to ripping the boards would have the added advantage of aiding in defect identification. The abrasive planer would also minimize the tear-out that would normally be expected if knives were used on the fairly knotty material.

During the second and third shifts, material from the lumber handling and storage system would be delivered to the stacker which loads the cauls. A roll case would transfer the lumber for the haul chain on which it was stacked to another haul chain which would reverse its flow and convey it to an unscrambler. This unscrambler would send one layer of boards to the accumulation chain and caul loading stacker.

The press dryer and accessory equipment would continue to operate as described above for the first shift. As the boards emerge from the abrasive planer, they would enter the woodworking department.

WOODWORKING

The woodworking department of this plant would contain equipment for ripping, side-matching, crosscutting, sorting, and end-matching the boards as well as accessory equipment for conveying, storage, and waste disposal.

It would employ 18 full-time workers plus a foreman. It would also utilize about 80 percent of a low lift truck operator's time and about 50 percent of the saw filer and tool grinder's time. Three of the 18 full-time workers would be required for each of the two late shifts.

As the boards emerge from the abrasive planer, they would be conveyed to a 3-chain spreader conveyor. This would spread the lumber and deliver it to a preselection shadow line section where the ripping cuts would be determined.

The shadow line section would include a guide line conveyor, a retractable fence, and a guide line light assembly. The guide line conveyor would take a board and bear it against a fixed stop so that the preselection shadow lines may be arranged for the desired ripping pattern.

The ripping pattern would be set by a ripsaw operator who scans each board and then pushes buttons on a control panel to move the shadow lines of the guide line light assembly to where he decides the cuts should be made. After the shadow lines are set, the operator would manually lift the leading edge of each board to allow chains

to move it onto a set of rubber covered carryover wheels which would carry it over the fixed stop and onto a set of lift chains. The lift chains would carry the board over to the ripsaw fence where it would be automatically dropped onto the ripsaw infeed roller conveyor as soon as the previous board clears the ripsaw.

The ripsaw would have one fixed and up to six movable blades which would automatically adjust themselves to rip the board where the shadow lines had been placed. The infeed guide fence would also be adjustable. It would be operated by the ripsaw setworks and could move a maximum of 15/16 inches in 1/16-inch increments. This would allow an edging strip up to 1 inch in width to be removed by the stationary saw.

A prerip edger with setworks is also included with the selective ripsawing equipment. It would be operated from the same control panel as the saws. One edger head would be fixed ahead of the stationary saw and would reduce the edging strip along the fence into chips for easy disposal by the dust collection system. The other edger head would be movable and would be set using the control panel and a shadow line to chip up the other edging strip.

Each board would emerge from the saw cut into the desired combination of the four specified widths required for the paneling (2 3/8-, 3 3/8-, 4 3/8-, and 6 3/8-inches). The ripped boards would then be stacked according to width on portable skids. Two men, one on each side of the outfeed conveyor and sorting tables, would be

required for sorting and stacking. The stacked boards would then be moved by the low lift truck operator to temporary storage on the skids.

This ripping operation would operate all three shifts in order to handle the continuous flow of material from the press drying department. During the second and third shifts the low lift truck could be operated by one of the lumber stackers and would not require a separate operator.

The ripping equipment described above would utilize some of the most sophisticated equipment available for this type of operation. Three alternative types of ripping operations were considered before this one was selected. These were: (1) enough single straight line ripsaws to keep up with the material emerging from the abrasive planer, (2) one straight-line gang ripsaw with up to 10 immovable saws on a wide arbor and (3) a combination of a gang ripsaw and one or more single straight-line ripsaws.

The first of these alternatives would probably require four saws with a sawyer and offbearer for each saw. The equipment would actually cost less than that included in the layout, but the additional floor space and 13 extra men required for a three-shift operation made this alternative very undesirable. The yield would be the same as that from the equipment selected for the layout, but the edging strips would create a disposal problem.

The second alternative would be the least expensive, but the yield would be reduced substantially. The sawyer could use the saw

next to the throat like a single straight-line ripsaw when he had time to cut for maximum yield, but most of the boards would have to be quickly positioned and run through the gang of saws. Two offbearers would be required for sorting, stacking, and returning the boards. The edgings would also still require manual handling. This alternative was rejected because it appeared to be too inflexible for getting a satisfactory yield from the low-quality material that would be sawn.

The third alternative would give the gang saw operator more time to position each board and would increase the yield somewhat over the second alternative. Two offbearers would still be required for the gang saw, and one sawyer and one offbearer would be needed for each single straight-line ripsaw. The more straight-line ripsaws included, the higher the yield but this higher yield would be accompanied by higher costs for machinery, floor space, and labor.

Needless to say, comparative cost and yield data for a real sound decision between the four ripsawing methods discussed above are not available. The ripping operation included in the layout for calculating the cost estimates would be one process warranting further consideration if someone decided to build a plant.

The ripping operation and the drying department are the only parts of the plant designed to operate three shifts per day. The remaining equipment is designed for a one-shift operation.

After ripping, the next processing step would be machining the tongue and groove and eased edge on the sides of the boards. One width at a time would have to be run through the matcher. For this, one of the lower priced medium capacity planers and matchers would work. Since the boards would already have been surfaced by the abrasive planer, only the two opposed matching heads would be required for the pattern designed by Heebink. This would eliminate the need for planing knives and their arbor motors and result in just a matching machine. If, however, it was decided that stress relief grooves should be put into the back side of the paneling, one of the planing knife positions could be used instead of an additional profiling attachment.

Boards from the matcher would flow out through a booster roll which would even-end them on a wide belt conveyor. This conveyor would carry them past four chop saw operators who would pick them up manually, and place them on their saw infeed tables. Boards not picked up by one operator would have to be picked up by a subsequent operator.

Each chop saw would have an outfeed layup angle with lumber stops to aid in cutting the boards to the six desired lengths (16 3/8-, 32 3/8-, 48 3/8-, 64 3/8-, 80 3/8-, and 96 3/8-inches) as the defects are cut out. The scrap would fall into a waste conveyor and the usable boards would fall onto another wide belt conveyor from which they would be conveyed to a length sorting conveyor.

The length sorting conveyor would drop each length into separate bins from which the boards would have to be removed manually and stacked onto portable skids.

The boards would then be fed one length at a time through a special double-end matching machine. A double-end machine has been included for end-matching because a conventional end matcher used for truly random length strip flooring would not machine the paneling lengths to the tolerances needed for an attractive installation.

As the boards emerge from the end matcher, they would be picked up and graded into at least two grades. The market survey portion of this study revealed markets for at least two grades. The clearer grade would correspond roughly to No. 2 Common and Better grades of oak flooring and would be used primarily for flooring. It will subsequently be referred to as the flooring grade. The other grade would contain the character-marked material suitable only for paneling and will be referred to as the paneling grade.

The grader would pile each grade separately on a grading table. They would then be removed from the table and stacked on portable skids by a lumber stacker. The portable skids would then be taken to a storage area where the material would be stored prior to prefinishing.

PREFINISHING

The prefinishing department of this plant contains all the applicating machines, ovens, and conveying equipment needed to sand, fill, stain, seal, finish coat, and polish the FPL paneling. Not all the paneling would undergo all these operations. Substantial amounts of both the paneling and the flooring grades would be given a natural finish and not need staining. Also, only the flooring grade would be filled.

The prefinishing line in the layout is designed to accommodate a 48-inch wide continuous flow of paneling which would be laid up on the loading conveyor. The flooring grade would be filled and either stained or sealed on one pass through the line. A pigmented stain should be used for this grade if the color is to wear well as flooring. Another cycle would be required for the sealer if the material was stained. The finish coat would also require a separate cycle. Hence, stained flooring would require three passes through the prefinishing line, while naturally finished flooring would require only two. A dye type stain could be mixed with the sealer for the paneling grade, so it would require a 2-cycle operation.

Prior to finishing, a selection would have to be made regarding the number of various size pieces that would be needed for each lot. This selection would be dependent upon the sizes available and could be very flexible. Its sole purpose would be to make sure that enough of each size is available to make packages that would result in attractive

installations. For this, the distribution of the various sizes would have to be fairly uniform from package to package.

The prefinishing line is designed to operate at 22 feet per minute for the staining and sealing cycles and at 11 feet per minute for the finish coat cycle. This will achieve the following finishing schedules:

A. Finish sand wood at the beginning of first cycle.

B. Wood filler (flooring grade only)

1. Apply with reverse roll coater.
2. Sixty seconds for drying in infra-red oven.
3. Brush-vacuum on sander-polisher to smooth surface.

C. Pigmented stain

1. Preheat wood in infra-red oven to 100 - 110° F. (Achieved by extending B2 to 120 seconds.)
2. Reciprocating airless spray application of stain to top surface of wood.
3. Forty-five seconds on open conveyor.
4. Sixty seconds in infra-red flashoff section.
5. Forty-five seconds in infra-red ovens to obtain a minimum of 150° F.
6. Ninety seconds on an open conveyor to cool down with fans to 110 - 115° F.
7. Sand down fibers raised by stain.

D. Face Sealer

1. Preheat wood to 110 - 115° F. in infra-red oven.
2. Roll coater application of sealer to back surface of wood.
3. Reciprocating airless spray application of sealer to top surface of wood.
4. Forty-five seconds on open conveyor.
5. Sixty seconds in infra-red flashoff section.
6. Forty-five seconds in infra-red ovens obtaining a minimum of 150° F.
7. Ninety seconds on an open conveyor to cool down with fans to 110 - 115° F.
8. Sand down fibers raised by sealer.

E. Finish coat (catalyzed synthetic varnish)

1. Preheat wood to 110 - 115° F. in infra-red oven.
2. Roll coater application of sealer to back surface of wood.
3. Reciprocating airless spray application of finish coat to top surface of wood.
4. Ninety seconds on open conveyor.
5. One hundred and twenty seconds in infra-red flashoff section.
6. Ninety seconds in infra-red oven obtaining a minimum of 150° F.
7. One hundred and eighty seconds on an open conveyor to cool down with fans to 100 - 110° F.
8. Buff with brush when satin finish is desired.

Paneling would be transported to the loading conveyor for the first cycle and between the unloading and loading conveyors for subsequent cycles on portable skids. Temporary storage and movement of these skids would be facilitated by a heavy duty gravity roller conveyor on which the skids could be placed. The skids would have to be taken to and from this conveyor by the low lift truck which would have to pick them up at the unloading station and place them at the loading station.

Needless to say, the prefinishing line shown in the layout is only one of many possible combinations of equipment that could perform this function. It is based, however, on an existing line used by the Townsend Lumber Company in Stuttgart, Arkansas, to prefinish their line of solid hardwood paneling. Certain modifications, such as adding wood filling equipment, have been made to meet the needs of this particular product.

The relative prices of gas and electricity at the plant's location would determine whether or not all the ovens should be

heated by infra-red lamps. It would be possible to use a gas heated force flashoff oven.

It would also be possible to use a curtain coater instead of a spray booth. Its initial cost would be from $1,000 to $2,000 higher, but it would reduce the finishing material costs by eliminating over-spray losses.

This prefinishing department is designed to prefinish an average of 10,000 square feet of paneling per day. It would require three full-time workers; one to lay up the paneling on the loading conveyor, one to handle the finishing materials and monitor the equipment, and one to unload the paneling at the end of the line. A foreman would divide his time equally between this and the packaging and warehouse department, the low lift truck operator would spend about 20 percent of his time moving loaded skids in this department, and two other men would be needed to help load and unload the paneling when the conveyors were running at finish coat speed or were handling the smaller pieces. The part-time loader and unloader would spend about 50 percent of their time in this department and their remaining time working for the plant's general maintenance foreman.

As the paneling completes its last cycle through the prefinishing line, it would be stacked again on portable skids and taken to the warehouse for packaging, storage, and shipping.

PACKAGING AND WAREHOUSING

Lots of paneling, either unfinished or with a certain pre-finishing treatment, would be taken to the warehouse for packaging. A tally of the various size pieces in each lot would be used to compute a packaging formula. This formula must give fairly specific instructions about the size and arrangement of pieces to be assembled for each of the eight layers in the packages. This would be needed to make the distribution of the various sizes fairly uniform from package to package. Without this uniformity some unattractive patterns could result if the paneling was installed per the instructions given in Heebink and Compton's report.[5/] For example, uncontrolled packaging could result in a concentration of large boards in one section of a wall and a concentration of small boards in another section.

Also, the flooring grade would have to be packaged much more carefully than the paneling grade. The market survey revealed that many of the joints that could occur in a truly random installation would be objectionable. For example two 3-inch boards end-matched to two more 3-inch boards would make an unacceptable flooring joint. On the other hand, a 6-inch board end-matched to two 3-inch boards or a 2-inch and a 4-inch board would make a very attractive joint.

5/ Op. cit.

The packaging and warehouse department would employ five full-time men plus the foreman who would divide his time equally between this and the finishing department. One man would keep the sorting bins filled with the various size pieces. Two men would assemble the boards in corrugated cartons and two more would close the cartons and stack them on pallets. One of these last men would also operate the warehouse lift truck.

CAPITAL REQUIREMENTS

The capital requirements for a new plant like that illustrated by the layout are shown in Tables 6 through 13. All the descriptive literature, equipment layouts, and price information obtained from numerous machinery manufacturers are on file at the Forest Products Marketing Laboratory. A list of these manufacturers is contained in Appendix B.

Table 6 summarizes the capital requirements for preliminary engineering, marketing, and plant location studies; construction of the physical plant; and for working capital. The physical plant estimates are broken down to show site and building costs as well as the installed costs of the equipment for each department. The working capital requirement was computed by getting the present value of the excess of operating, sales, and advertising costs over sales receipts during the construction period and the first year of the plant's operation. It, therefore, includes allowances for a fairly intensive advertising program and for building up adequate inventories of raw material, in-process materials, and the finished products. The total capital requirement shown in this table is $1,300,000. This includes $30,000 for preliminary studies, $922,000 for the physical plant, and $348,000 for working capital.

Table 7 shows the building costs for each department. These costs include foundations, heating and venilation equipment, conduit wiring for lights and power; and an automatic sprinkling system. The

Table 6.--Summary of capital requirements for the FPL paneling plant

Item	Installed cost
Prepared site (5 acres)	$ 10,000
Building and building services	198,000
Sawmill equipment	155,000
Press drying equipment	250,000
Woodworking equipment	180,000
Finishing equipment	109,000
Packaging and shipping equipment	10,000
Office equipment and supplies	10,000
Total investment in physical plant	922,000
Preliminary engineering, marketing, and plant location studies	30,000
Working capital	348,000
TOTAL CAPITAL REQUIREMENTS	$1,300,000

Table 7.--Building costs

Building function	Square feet	$/square foot	Cost
Office	2,040	$10.75	$ 22,000
Sawmill	4,125	8.55	35,200
Drying	2,675	8.55	22,800
Woodworking	6,780	8.55	58,000
Finishing	4,320	4.95	21,300
Warehouse	6,480	4.95	32,000
Boiler room	1,050	6.35	6,700
TOTAL	27,470	$ 7.21	$198,000

office portion also includes air conditioning. These costs were obtained using Boechk's Manual of Appraisals[6/] and its September 1966 Building Cost Index Supplement. The Atlanta, Georgia cost index figures were used because they are the most accurate for southern West Virginia and western Virginia. The Atlanta index was about 7 percent and 15 percent lower, respectively, than the Louisville, Kentucky and Pittsburgh, Pennsylvania indices, and 10 percent higher than the Richmond, Virginia index for steel commercial and factory buildings. The total building cost estimate is $198,000. This averages about $7.21 per square foot for 27,470 square feet.

Table 8 shows the costs of machinery for the sawmill department plus freight and installation charges and the pro rata share of site and building costs. The total estimated costs for this department amount to $195,700.

Table 9 shows the net effect of including a chipping system in the sawmill department. If this system was excluded, it would lower the total installed costs shown in Tables 6 and 8 by $28,000.

6/ Boechk, E. H. Boechk's manual of appraisals, 5th edition, New York, 840 pp., 1956.

Table 8.--Sawmill machinery for FPL paneling plant

Item	Machinery cost
Forklift truck	$ 12,200
Live deck	1,900
Debarker	9,600
Live deck	2,300
Log turner with stop and loader	3,100
Log carriage with drive and track	9,500
Saw husk and drive with tailing device	3,300
Main roll case with slab and cant unloaders	6,300
Cant transfer	1,600
Gang saw infeed rolls	1,200
Sash gang saw with drive	23,400
Gang saw outfeed rolls	2,700
Lumber transfer to edger	1,400
Edger with tailing device	2,700
Lumber transfer to drying department	2,000
3 circular saws	1,200
50 gang saw blades	1,300
Filing room equipment	5,900
Tanner gas system	100
Air compressor	500
Waste conveyors	15,500
Refuse burner	8,200
Chipping equipment	12,800
Miscellaneous tools and equipment	500
Total	$129,200
Freight charges	5,300
Installation and wiring costs	20,500
Total installed cost	$155,000
Building cost (4,125 square feet at $8.55)	35,700*
Pro rata share of site cost	5,000
Total initial investment in the physical plant for the sawmill department	$195,700

* Includes pro rata share of boiler room.

Table 9.--Net effect of chipping system on FPL paneling plant

Item	Machinery price
Additional Equipment Required	
Live deck	$ 1,900
Debarker	9,600
Waste conveyors	1,200
Slab conveyor	900
Chipper with motor and ducts	6,600
Cyclone collector	600
Chip screen with motor	2,000
Chip loading conveyor	2,000
Other conveyors	700
Total equipment costs	$25,500
Freight and installation costs	7,500
Total installed cost	$33,000
Reduction in Other Equipment Needs	
Refuse burner	$ 4,000
Freight and installation costs	1,000
Total cost reduction	$ 5,000
Net effect of chipping system on initial investment for sawmill department	$28,000

Table 10 shows the costs of press drying and accessory surfacing and lumber handling equipment for the press drying department. It also shows this department's pro rata share of the site and building costs. For the reasons discussed in the section on production methods, the surfacing and lumber handling equipment were included in this section to make the production cost estimates comparable to kiln drying costs for 1/2-inch red oak.

Nine press manufacturing companies were asked for price information and specifications for a press to perform the drying functions indicated by Heebink and Compton. Five responded with price estimates ranging from $33,800 to $96,000. Not all of these estimates were for presses modified to just meet the drying requirements of 350° F. and 50 p.s.i. The figure chosen was based on a precontractual quotation from a manufacturer who worked up a preliminary design and detailed specifications for a lumber drying press. Due to a dearth of knowledge about press drying schedules and the lack of any commercially operating press dryers in this country, this process will require further study before more accurate cost information can be obtained.

The abrasive planer also adds significantly to the cost of equipment for the press drying department. Although it has only an 18-inch capacity, the opposed heads for removing equal amounts of stock from both surfaces of the boards result in a price of $29,300. The total installed cost of the physical plant for this department is estimated at $276,500.

Table 10.--Press drying machinery for FPL paneling plant

(includes special surfacing equipment)

Item	Machinery price
Single surfacer	$ 3,300
Lumber handling and storage conveyors	41,000
Caul circulation conveyors	16,900
Ventilated cauls	5,000
Press loading conveyors	14,500
20-opening press dryer	59,200
Press unloading conveyors	14,500
Abrasive planer	29,300
Steam generator	21,000
Miscellaneous tools and equipment	300
Total equipment costs	$205,000
Freight charges	10,000
Installation and wiring	35,000
Total installed machinery cost	$250,000
Building cost (4,125 square feet at $8.55)	26,200*
Site cost (pro rata share)	300
Total initial investment in the physical plant for the drying department	$276,500

* Includes pro rata share of boiler building

Table 11 shows the equipment prices, freight, and installation charges, and the pro rata share of the building and site costs for the woodworking department. Except for the ripsawing operation discussed in detail in the section on production methods, the only operation that might be performed by a number of makes and models of machines with widely divergent prices is the end-matching. Ten manufacturers submitted price quotations on the double-end machine they would recommend and these quotations ranged from $3,600 to $21,100. The machine selected for cost estimating purposes would cost $12,000. Several of the machine quotations were grouped around this figure. At this price, it is possible to get a high quality double-end machine modified to perform just an end-matching operation.

The total cost of the physical plant for the woodworking department is estimated at $240,000.

Table 12 shows the equipment prices, freight and installation costs, and the pro rata share of the building and site costs for the prefinishing department. These cost estimates total $131,500.

Table 13 shows similar data for the packaging and warehouse department. These cost estimates total $46,000 with the main item being the cost of the building.

The office portion of the plant is not shown in a table, but its estimated cost is $32,300. This includes $22,300 for the building and $10,000 for office equipment.

Table 11.--Woodworking machinery for FPL paneling plant

Item	Machinery price
Chain spreader conveyor	$ 2,200
Guide line conveyor	2,700
Guide line light assembly	8,000
Powered roller conveyor	2,900
Prerip edger with setworks	10,300
Selective multiple ripsaw with setworks	20,500
Belt conveyor with stacking tables	1,500
Matcher infeed table	2,000
Matcher with cutterheads and knives	11,000
Booster roll	800
Wide belt conveyor	2,300
4 chop saws with infeed and outfeed tables	4,400
Wide belt conveyor	2,600
Belt conveyor	2,100
Automatic length sorting conveyor	10,500
Double-end matcher	13,000
Molder with cutterheads and knives	4,600
Low lift truck	3,600
Dust disposal system	36,500
Air makeup unit	6,000
Cutterhead grinder	700
Wood skids	300
Miscellaneous tools and equipment	500
Scrap conveyor	1,000
Total machinery cost	$150,000
Freight charges	6,200
Installation and wiring cost	23,800
Total installed cost	$180,000
Building cost (6,780 square feet @ $8.55)	59,000*
Site cost (pro rata share)	1,000
Total initial investment in the physical plant for the woodworking department	$240,000

* Includes pro rata share of boiler room.

Table 12.--Finishing machinery for the FPL paneling plant

Item	Machinery price
Loading conveyor	$ 1,400
Wide belt sander	25,700
Brush dusting machine	2,700
Reverse roll filling machine	8,600
Infra-red oven	4,500
Oven conveyor	2,800
Sander-polisher	7,700
Bottom roll coater	2,600
Spray booth and equipment	6,600
Ventilated flash enclosure	1,100
Forced flash oven	2,800
Infra-red curing oven	3,900
Main oven and cooling conveyor	7,200
Sander-polisher	7,700
Unloading conveyor	1,400
Total inline machines	$ 86,700
Return and storage conveyor	3,000
Wooden skids	100
Air makeup unit	2,000
Miscellaneous tools and equipment	100
Total finishing equipment cost	$ 92,000
Freight charges	3,800
Installation and wiring	13,200
Total installed cost	$109,000
Building 4,320 square feet @ $4.95)	21,900*
Site (pro rata share)	600
Total initial investment for the physical plant for the prefinishing department	$131,500

* Includes pro rata share of boiler building.

Table 13.--Packaging and warehousing equipment for the FPL paneling plant

Item	Machinery price
2 factory trucks	$ 200
Panel sorting bins	400
Roll conveyor	1,000
Tape dispenser	100
Storage pallets	500
Lift trucks	7,300
20 wooden skids	100
Total equipment costs	$ 9,600
Freight charges	200
Installation and wiring	200
Installed equipment cost	$10,000
Building cost (6,480 square feet @ $4.95)	32,900*
Site cost (pro rata share)	3,100
Total initial investment in the physical plant for the packaging and warehousing department	$46,000

* Includes pro rata share of boiler building costs

The totals shown in Tables 8 through 13, excluding Table 9, plus the $32,300 for the office portion of the plant add up to $922,000. This is shown as the total investment required for land, building, and equipment in Table 6.

STAFF AND PAYROLL REQUIREMENTS

The estimated annual payroll including the employer's contributions, is shown in Table 14. The employer's contributions include payments for social security, unemployment insurance, workmen's compensation, and in the case of key personnel, life insurance. The total payroll costs, including these contributions, would be about $307,000.

Table 15 shows a complete breakdown of the personnel needed for each department and their estimated costs. The job numbers correspond with those shown in circles in the layout which indicate the working station or the general working area for each person.

Table 14.--Annual payroll for the FPL paneling plant by department

No. of men*	Department	Annual pay	Employer's contribution	Total payroll costs
6.0	Office	$ 54,200	$ 8,000	$ 62,200
8.1	Sawmill	35,900	5,400	41,300
3.4	Drying	15,800	2,400	18,200
20.3	Woodworking	79,500	12,000	91,500
4.7	Finishing	17,400	2,600	20,000
5.5	Packaging and shipping	21,200	3,200	24,400
2.0	Maintenance	7,500	1,100	8,600
4.0	Sales and advertising	35,900	4,800	40,700
54.0	TOTAL	$267,400	$39,500	$306,900

* Fractional men are indicated because several would divide their time between two departments.

Table 15.--Personnel and payroll requirements for the FPL paneling plant

Job No.	Job title	Annual pay	Employer's * contributions	Total payroll costs
	OFFICE STAFF			
1	General Manager	$20,000	$ 2,800	$22,800
2	Plant Manager	12,500	1,900	14,400
3	Quality Control Engineer	8,200	1,250	9,450
4	Business Manager	6,500	1,000	7,500
5	Bookkeeper	4,000	600	4,600
6	Receptionist-Switchboard	3,000	450	3,450
	Office total	$54,200	$ 8,000	$62,200
	SAWMILL DEPARTMENT			
7	Sawmill and Drying Foreman (60%)**	$ 3,900	$ 590	$ 4,490
8	Log Procurement Forester	6,000	900	6,900
9	Forklift Operator	4,200	630	4,830
10	Debarker Operator	4,200	630	4,830
11	Head Sawyer	4,500	680	5,180
12	Sash Gang Feeder	3,400	510	3,910
13	Sash Gang Offbearer	3,000	450	3,450
14	Edgerman	4,500	680	5,180
15	Saw filer and Tool grinder (50%)**	2,200	330	2,530
	Department total	$35,900	$ 5,400	$41,300
	PRESS DRYING DEPARTMENT			
7	Sawmill and Drying Foreman (40%)**	$ 2,600	$ 410	$ 3,010
16	Day Shift Operator	4,200	630	4,830
17	Evening Shift Operator	4,500	680	5,180
18	Night Shift Operator	4,500	680	5,180
	Department total	$15,800	$ 2,400	$18,200
	WOODWORKING DEPARTMENT			
19	Woodworking Foreman	$ 6,500	$ 980	$ 7,480
20	Day Shift Ripsawyer	4,700	710	5,410
21	Evening Shift Ripsawyer	5,000	750	5,750
22	Night Shift Ripsawyer	5,000	750	5,750
23	Day Shift Lumber Stacker	3,000	450	3,450
24	Day Shift Lumber Stacker	3,000	450	3,450
25	Evening Shift Lumber Stacker	3,200	480	3,680
26	Evening Shift Lumber Stacker	3,200	480	3,680
27	Night Shift Lumber Stacker	3,200	480	3,680

Table 15 -- Continued

Job No.	Job title	Annual pay	Employer's* contributions	Total payroll costs
	WOODWORKING (continued)			
28	Night Shift Lumber Stacker	$ 3,200	$ 480	$ 3,680
29	Matcher Feeder	3,000	450	3,450
30	Chop Sawyer	4,500	680	5,180
31	Chop Sawyer	4,500	680	5,180
32	Chop Sawyer	4,500	680	5,180
33	Chop Sawyer	4,500	680	5,180
34	Lumber Stacker	3,000	450	3,450
35	End-Matcher Feeder	3,000	450	3,450
36	Grader and Offbearer	4,500	680	5,180
37	Lumber Stacker	3,000	450	3,450
38	Low Lift Truck Operator (80%)**	2,800	440	3,240
15	Saw Filer and Tool Grinder (50%)**	2,200	350	2,550
	Department total	$79,500	$12,000	$91,500
	FINISHING DEPARTMENT			
39	Finishing, Packaging & Shipping Foreman (50% for this department)	$ 3,200	$ 480	$ 3,680
40	Materials Handler	4,500	680	5,180
41	Loader	3,000	450	3,450
42	Loader - Maintenance (50%)**	1,500	220	1,720
43	Unloader	3,000	450	3,450
44	Unloader and Maintenance (50%)**	1,500	220	1,720
38	Low Lift Truck Operator (20%)**	700	100	800
	Department total	$17,400	$ 2,600	$20,000
	PACKAGING AND SHIPPING DEPARTMENT			
39	Finishing, Packaging & Shipping Foreman (50%)**	$ 3,200	$ 480	$ 3,680
45	Sorting Bin Filler	3,000	450	3,450
46	Packer	4,100	620	4,720
47	Packer	4,100	620	4,720
48	Stacker	3,000	450	3,450
49	Stacker and Lift Operator	3,800	580	4,380
	Department total	$21,200	$ 3,200	$24,400

Table 15 -- Continued

Job No.	Job title	Annual pay	Employer's* contributions	Total payroll costs
	MAINTENANCE DEPARTMENT			
50	Maintenance Foreman	$ 4,500	$ 680	$ 5,180
42	Loader and Maintenance (50%)**	1,500	210	1,710
44	Unloader and Maintenance (50%)**	1,500	210	1,710
	Department total	$ 7,500	$ 1,100	$ 8,600
	SALES AND ADVERTISING DEPARTMENT			
51	Sales and Advertising Manager	$ 12,500	$ 1,900	$ 14,400
52	Sales Representative	10,000	1,200	11,200
53	Sales Representative	10,000	1,200	11,200
54	Secretary	3,400	500	3,900
	Department total	$ 35,900	$ 4,800	$ 40,700
TOTAL ANNUAL PAYROLL		$267,400	$39,500	$306,900

* Includes payments for social security, unemployment insurance, workman's compensation, and in the case of key management personnel, life insurance.

** Indicates percent of this person's time and salary allocated to this department.

PRODUCTION COSTS

METHOD OF COMPUTATION

The average per square foot production costs for the FPL paneling were computed using a discounted cash flow method. All the cash expenditures estimated for each department of the plant were discounted to a present value, V_o, at time T_o. T_o is the point in time at which the decision to build the plant would be made. All estimated costs, C_t, that would arise from a decision to build and operate a plant were discounted to T_o using the formula:

$$V_o = C_o + \frac{C_{.5}}{(1 + i/2)^{2(.5)}} + \frac{C_1}{(1 + i)^1} + \frac{C_{1.5}}{(1 + i/2)^{2(1.5)}} +$$

$$+ \frac{C_2}{(1 + i)^2} + \frac{C_3}{(1 + i)^3} + \ldots\ldots\ldots + \frac{C_{27}}{(1 + i)^{27}}$$

The subscript t in C_t is expressed numerically to indicate the length of time in years this expenditure would occur after T_o. The exponents in the denominators, except for the second and fourth terms on the right hand side of the equation, are also numerically equal to the subscript used in the numerator. The rate of interest used for discounting is designated by i.

The second and fourth terms on the right hand side of the formula represent the present values of the expenditures that are discounted from $T_{.5}$ and $T_{1.5}$, respectively. These terms have been modified to account for the 1/2-year intervals by using i/2 and 2t and closely

approximate the mathematically correct present values of $C_{.5}$ and $C_{1.5}$. The mathematical error of this procedure is insignificant when compared to the possible errors in the estimates of $C_{.5}$ and $C_{1.5}$.

Expenditures were estimated at 1/2-year intervals from T_o to T_2 because of the large and erratic expenditures that would be incurred during this period. C_o includes the costs of the preliminary engineering, marketing, and plant location studies that would be made prior to T_o, as well as the cost of land, insurance, legal fees and other miscellaneous items that would be purchased at T_o. $C_{.5}$ and C_1 include the large capital outlays for plant construction. $C_{1.5}$ and C_2 include the irregular but rapidly increasing operating costs that would be incurred during the plant's first year of operation.

The present value, V_o, of the office and other miscellaneous overhead expenses was allocated to the various production and sales departments in proportion to their respective present values. The present values for these departments, including their pro rata share of the overhead expenses, were then converted to V_1, or their value at the time T_1 when plant construction would be completed and actual paneling production would begin. The following formula was used for this conversion:

$$V_1 = (1 + i)\ (V_o)$$

The estimated economic life of the plant was determined to be 25 years by observing the differences between operating expenses

(Table 23) and sales revenue (Table 2). If the plant were built, the cash flows shown in these tables indicate that after T_{26} sales revenue would no longer exceed current operating expenses. Rational plant management would then cease operations and liquidate their physical assets, or else undertake a major plant renovation or replacement program. For purposes of this analysis, a liquidation of assets was assumed with the sales revenue from land, buildings and equipment treated as a negative expense for T_{27}.

Level annual production costs for the period of plant operation were obtained by using the following formula:

$$\text{Level annual costs} = \frac{(V_1)\ (i)\ (1 + i)^{25}}{(1 + i)^{25} - 1}$$

These level annual costs were then divided by the output of each department and by the paneling production figures to obtain the estimated costs per square foot.

Originally, the intention was to compute the present value of the net cash flows (sales revenue minus expenses) for this plant at several interest rates, so that prospective manufacturers could compare it with alternative investments at the rate of interest which applied for their particular situation. The first computation was made using a 6 percent rate which was assumed to be the lowest before tax rate that any manufacturer might have as his cost of capital. This rate would be applicable only for a very large corporation with

with an excellent credit rating that could borrow most, if not all, the capital requirements at a very favorable long-term rate.

Even at this low rate, the present value was negative. It was then decided that just estimating production costs for the various departments would be sufficient. These estimates will not only indicate that manufacturing the FPL paneling as outlined in the production methods section is not economically feasible, but they may also be of value to manufacturers contemplating similar operations for somewhat different raw materials and/or products.

CASH FLOW ESTIMATES

Tables 16 through 22 show all the cash flow estimates for overhead expenses, each of the five production departments, and the sales department. The overhead expenses consist of those incurred by the office and general maintenance departments.

The figures shown in these tables form the basis for the production cost estimates. They include all the estimated costs that would be incurred from the time a company seriously begins to study the possibility of manufacturing the paneling until the economic life of the plant has expired and the physical assets have been liquidated. These costs are shown for the years in which it is estimated they would be incurred. The total costs incurred each year by each department are then converted to a present value for T_o using a 6 percent rate of interest.

Table 16.--Estimate of actual cash flow for overhead expenses
(Office and miscellaneous)

Year (T)	Prelim. engin. market. & location studies	Payroll	Temp. offices	Insurance	Prop. taxes and lic. fees	Office area of bldg.	Office equipment	Office supplies	Travel expenses	Util.	Teleph.	Legal and Audit	TOTALS	Present values
0	30,000	--	--	2,000	200	--	1,000	100	--	--	--	1,000	34,300	34,300
.5	--	25,000	1,000	2,500	--	10,000	--	100	1,000	--	1,000	--	40,600	39,400
1	--	27,000	1,000	4,500	9,000	12,300	9,000	100	1,000	--	1,000	300	65,200	61,500
1.5	--	35,400	--	4,500	--	--	--	100	1,000	500	1,000	--	42,500	38,900
2	--	35,400	--	9,000	18,000	--	--	200	1,000	500	500	500	65,100	57,900
3	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	86,200
4	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	81,300
5	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	76,600
6	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	72,300
7	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	68,200
8	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	64,300
9	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	60,700
10	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	57,200
11	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	54,100
12	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	51,000
13	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	48,100
14	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	45,300
15	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	42,800
16	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	40,400
17	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	38,100
18	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	35,900
19	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	33,900
20	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	32,000
21	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	30,200
22	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	28,500
23	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	26,900
24	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	25,300
25	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	23,900
26	--	70,800	--	9,000	18,000	--	100	200	2,000	1,000	1,000	500	102,600	22,600
27	--	22,500	--	--	--	-6,700	--	--	--	--	--	--	15,800	3,300

Table 17.--Estimate of actual cash flow for sawmill expense

Year (T)	Payroll	Land	Building	Equipment	Logs	Electric power	Gas	Repairs and maintenance	Other supplies	Diesel fuel	TOTAL	Present value
0	--	5,000	--	--	--	--	--	--	--	--	5,000	5,000
.5	--	--	20,000	13,000	--	--	--	--	--	--	33,000	32,000
1	4,300	--	15,700	142,000	12,000	--	--	--	--	100	174,100	164,200
1.5	20,600	--	--	--	37,500	3,000	--	700	400	300	62,500	57,200
2	20,700	--	--	--	37,500	3,200	500	1,400	400	300	64,000	57,000
3	41,300	--	--	--	75,000	6,400	500	2,100	800	600	126,700	106,400
4	41,300	--	--	--	75,000	6,400	500	2,800	800	600	127,400	100,900
5	41,300	--	--	--	75,000	6,400	500	3,500	800	600	128,100	95,700
6	41,300	--	--	--	75,000	6,400	500	4,200	800	600	128,800	90,800
7	41,300	--	--	--	75,000	6,400	500	4,900	800	600	129,500	86,100
8	41,300	--	--	--	75,000	6,400	500	5,600	800	600	130,200	81,700
9	41,300	--	--	--	75,000	6,400	500	6,300	800	600	130,900	77,500
10	41,300	--	--	--	75,000	6,400	500	7,000	800	600	131,600	73,500
11	41,300	--	--	--	75,000	6,400	500	7,700	800	600	132,300	69,700
12	41,300	--	--	--	75,000	6,400	500	8,400	800	600	133,000	66,100
13	41,300	--	--	--	75,000	6,400	500	9,100	800	600	133,700	62,700
14	41,300	--	--	--	75,000	6,400	500	9,800	800	600	134,400	59,400
15	41,300	--	--	--	75,000	6,400	500	10,500	800	600	135,100	56,400
16	41,300	--	--	--	75,000	6,400	500	11,200	800	600	135,800	53,500
17	41,300	--	--	--	75,000	6,400	500	11,900	800	600	136,500	50,700
18	41,300	--	--	--	75,000	6,400	500	12,600	800	600	137,200	48,000
19	41,300	--	--	--	75,000	6,400	500	13,300	800	600	137,900	45,600
20	41,300	--	--	--	75,000	6,400	500	14,000	800	600	138,600	43,200
21	41,300	--	--	--	75,000	6,400	500	14,700	800	600	139,300	41,000
22	41,300	--	--	--	75,000	6,400	500	15,400	800	600	140,000	38,900
23	41,300	--	--	--	75,000	6,400	500	16,100	800	600	140,700	36,800
24	41,300	--	--	--	75,000	6,400	500	16,800	800	600	141,400	34,900
25	41,300	--	--	--	75,000	6,400	500	17,500	800	600	142,100	33,100
26	41,300	--	--	--	75,000	6,400	500	17,800	800	600	142,400	31,300
27	--	-5,000	-10,500	-7,000	--	--	--	--	--	--	-22,500	-4,700

Table 18.--Estimate of cash flow for drying expense

Year (T)	Payroll	Land	Building	Equipment	Electric power	Gas	Repairs and maintenance	Abrasives	Cauls	Other supplies	TOTAL	Present values
0	--	300	--	--	--	--	--	--	--	--	300	300
.5	--	--	12,800	20,000	--	--	--	--	--	--	32,800	31,800
1	1,500	--	13,400	230,000	--	--	--	--	--	--	244,900	231,000
1.5	9,100	--	--	--	4,000	7,000	1,300	1,200	1,200	400	24,200	22,100
2	9,100	--	--	--	4,200	7,200	2,600	1,300	2,400	400	27,200	24,200
3	18,200	--	--	--	8,400	14,300	3,900	2,500	4,800	800	52,900	44,400
4	18,200	--	--	--	8,400	14,300	5,200	2,500	4,800	800	54,200	42,900
5	18,200	--	--	--	8,400	14,300	6,500	2,500	4,800	800	55,500	41,500
6	18,200	--	--	--	8,400	14,300	7,800	2,500	4,800	800	56,800	40,000
7	18,200	--	--	--	8,400	14,300	9,100	2,500	4,800	800	58,100	38,600
8	18,200	--	--	--	8,400	14,300	10,400	2,500	4,800	800	59,400	37,300
9	18,200	--	--	--	8,400	14,300	11,700	2,500	4,800	800	60,700	35,900
10	18,200	--	--	--	8,400	14,300	13,000	2,500	4,800	800	62,000	34,600
11	18,200	--	--	--	8,400	14,300	14,300	2,500	4,800	800	63,300	33,300
12	18,200	--	--	--	8,400	14,300	15,600	2,500	4,800	800	64,600	32,100
13	18,200	--	--	--	8,400	14,300	16,900	2,500	4,800	800	65,900	30,900
14	18,200	--	--	--	8,400	14,300	18,200	2,500	4,800	800	67,200	29,700
15	18,200	--	--	--	8,400	14,300	19,500	2,500	4,800	800	68,500	28,600
16	18,200	--	--	--	8,400	14,300	20,800	2,500	4,800	800	69,800	27,500
17	18,200	--	--	--	8,400	14,300	22,100	2,500	4,800	800	71,100	26,400
18	18,200	--	--	--	8,400	14,300	23,400	2,500	4,800	800	72,400	25,400
19	18,200	--	--	--	8,400	14,300	24,700	2,500	4,800	800	73,700	24,400
20	18,200	--	--	--	8,400	14,300	26,000	2,500	4,800	800	75,000	23,400
21	18,200	--	--	--	8,400	14,300	27,300	2,500	4,800	800	76,300	22,400
22	18,200	--	--	--	8,400	14,300	28,600	2,500	4,800	800	77,600	21,500
23	18,200	--	--	--	8,400	14,300	29,900	2,500	4,800	800	78,900	20,700
24	18,200	--	--	--	8,400	14,300	31,200	2,500	4,800	800	80,200	19,800
25	18,200	--	--	--	8,400	14,300	32,500	2,500	4,800	800	81,500	19,000
26	18,200	--	--	--	8,400	14,300	33,000	2,500	4,800	800	82,000	18,000
27	--	-300	-7,700	-500	--	--	--	--	--	--	-8,500	-1,800

Table 19.--Estimate of actual cash flow for woodworking expenses

Year (T)	Payroll	Land	Building	Equipment	Gas	Electric power	Repairs & maintenance	Other supplies	TOTALS	Present values
0	--	1,000	--	--	--	--	--	--	1,000	1,000
.5	--	--	38,000	15,000	--	--	--	--	53,000	51,500
1	14,800	--	21,000	165,000	--	--	--	--	200,800	189,400
1.5	45,700	--	--	--	--	3,700	900	600	50,900	46,600
2	45,800	--	--	--	800	3,800	1,800	600	52,800	47,000
3	91,500	--	--	--	800	7,500	2,700	1,200	103,700	87,100
4	91,500	--	--	--	800	7,500	3,600	1,200	104,600	82,900
5	91,500	--	--	--	800	7,500	4,500	1,200	105,500	78,800
6	91,500	--	--	--	800	7,500	5,400	1,200	106,400	75,000
7	91,500	--	--	--	800	7,500	6,300	1,200	107,300	71,400
8	91,500	--	--	--	800	7,500	7,200	1,200	108,200	67,900
9	91,500	--	--	--	800	7,500	8,100	1,200	109,100	64,600
10	91,500	--	--	--	800	7,500	9,000	1,200	110,000	61,400
11	91,500	--	--	--	800	7,500	9,900	1,200	110,900	58,400
12	91,500	--	--	--	800	7,500	10,800	1,200	111,800	55,600
13	91,500	--	--	--	800	7,500	11,700	1,200	112,700	52,800
14	91,500	--	--	--	800	7,500	12,600	1,200	113,600	50,200
15	91,500	--	--	--	800	7,500	13,500	1,200	114,500	47,800
16	91,500	--	--	--	800	7,500	14,400	1,200	115,400	45,400
17	91,500	--	--	--	800	7,500	15,300	1,200	116,300	43,200
18	91,500	--	--	--	800	7,500	16,200	1,200	117,200	41,100
19	91,500	--	--	--	800	7,500	17,100	1,200	118,100	39,000
20	91,500	--	--	--	800	7,500	18,000	1,200	119,000	37,100
21	91,500	--	--	--	800	7,500	18,900	1,200	119,900	35,300
22	91,500	--	--	--	800	7,500	19,800	1,200	120,800	33,500
23	91,500	--	--	--	800	7,500	20,700	1,200	121,700	31,900
24	91,500	--	--	--	800	7,500	21,600	1,200	122,600	30,300
25	91,500	--	--	--	800	7,500	22,500	1,200	123,500	28,800
26	91,500	--	--	--	800	7,500	22,800	1,200	123,800	27,200
27	--	-1,000	-17,600	-17,500	--	--	--	--	-36,100	-7,500

Table 20.--Estimate of actual cash flow for finishing expenses

Year (T)	Payroll	Land	Building	Equipment	Finishing materials	Abrasives	Electric power	Gas	Repairs & maintenance	Other supplies	TOTALS	Present values
0	--	600	--	--	--	--	--	--	--	--	600	600
.5	--	--	11,300	9,000	--	--	--	--	--	--	20,300	19,700
1	1,300	--	10,600	100,000	--	--	--	--	--	--	111,900	105,500
1.5	10,000	--	--	--	15,000	700	3,400	--	500	200	29,800	27,300
2	10,000	--	--	--	31,000	800	3,500	500	1,000	300	47,100	41,900
3	20,000	--	--	--	62,000	1,500	6,900	500	1,500	500	92,900	78,000
4	20,000	--	--	--	62,000	1,500	6,900	500	2,000	500	93,400	74,000
5	20,000	--	--	--	62,000	1,500	6,900	500	2,500	500	93,900	70,100
6	20,000	--	--	--	62,000	1,500	6,900	500	3,000	500	94,400	66,600
7	20,000	--	--	--	62,000	1,500	6,900	500	3,500	500	94,900	63,100
8	20,000	--	--	--	62,000	1,500	6,900	500	4,000	500	95,400	59,800
9	20,000	--	--	--	62,000	1,500	6,900	500	4,500	500	95,900	56,800
10	20,000	--	--	--	62,000	1,500	6,900	500	5,000	500	96,400	53,800
11	20,000	--	--	--	62,000	1,500	6,900	500	5,500	500	96,900	51,000
12	20,000	--	--	--	62,000	1,500	6,900	500	6,000	500	97,400	48,400
13	20,000	--	--	--	62,000	1,500	6,900	500	6,500	500	97,900	45,900
14	20,000	--	--	--	62,000	1,500	6,900	500	7,000	500	98,400	43,500
15	20,000	--	--	--	62,000	1,500	6,900	500	7,500	500	98,900	41,300
16	20,000	--	--	--	62,000	1,500	6,900	500	8,000	500	99,400	39,100
17	20,000	--	--	--	62,000	1,500	6,900	500	8,500	500	99,900	37,100
18	20,000	--	--	--	62,000	1,500	6,900	500	9,000	500	100,400	35,200
19	20,000	--	--	--	62,000	1,500	6,900	500	9,500	500	100,900	33,300
20	20,000	--	--	--	62,000	1,500	6,900	500	10,000	500	101,400	31,600
21	20,000	--	--	--	62,000	1,500	6,900	500	10,500	500	101,900	30,000
22	20,000	--	--	--	62,000	1,500	6,900	500	11,000	500	102,400	28,400
23	20,000	--	--	--	62,000	1,500	6,900	500	11,500	500	102,900	26,900
24	20,000	--	--	--	62,000	1,500	6,900	500	12,000	500	103,400	25,500
25	20,000	--	--	--	62,000	1,500	6,900	500	12,500	500	103,900	24,200
26	20,000	--	--	--	62,000	1,500	6,900	500	12,700	500	104,100	22,900
27	--	-600	-6,600	-1,000	--	--	--	--	--	--	-8,200	-1,700

Table 21.--Estimate of actual cash flow for packaging and warehouse expenses

Year (T)	Payroll	Land	Building	Equipment	Packaging	Electric power	Gas	Repairs & maintenance	Other supplies	TOTALS	Present values
0	--	3,100	--	--	--	--	--	--	--	3,100	3,100
.5	--	--	17,000	--	--	--	--	--	--	17,000	16,500
1	1,300	--	15,900	10,000	--	--	--	--	--	27,200	25,700
1.5	12,200	--	--	--	11,600	400	--	100	100	24,400	22,300
2	12,200	--	--	--	23,800	400	700	200	100	37,400	33,300
3	24,400	--	--	--	47,500	800	700	300	200	73,900	62,000
4	24,400	--	--	--	47,500	800	700	400	200	74,000	58,600
5	24,400	--	--	--	47,500	800	700	500	200	74,100	55,400
6	24,400	--	--	--	47,500	800	700	600	200	74,200	52,300
7	24,400	--	--	--	47,500	800	700	700	200	74,300	49,400
8	24,400	--	--	--	47,500	800	700	800	200	74,400	46,700
9	24,400	--	--	--	47,500	800	700	900	200	74,500	44,100
10	24,400	--	--	--	47,500	800	700	1,000	200	74,600	41,700
11	24,400	--	--	--	47,500	800	700	1,100	200	74,700	39,400
12	24,400	--	--	--	47,500	800	700	1,200	200	74,800	37,200
13	24,400	--	--	--	47,500	800	700	1,300	200	74,900	35,100
14	24,400	--	--	--	47,500	800	700	1,400	200	75,000	33,200
15	24,400	--	--	--	47,500	800	700	1,500	200	75,100	31,300
16	24,400	--	--	--	47,500	800	700	1,600	200	75,200	29,600
17	24,400	--	--	--	47,500	800	700	1,700	200	75,300	28,000
18	24,400	--	--	--	47,500	800	700	1,800	200	75,400	26,400
19	24,400	--	--	--	47,500	800	700	1,900	200	75,500	25,000
20	24,400	--	--	--	47,500	800	700	2,000	200	75,600	23,600
21	24,400	--	--	--	47,500	800	700	2,100	200	75,700	22,300
22	24,400	--	--	--	47,500	800	700	2,200	200	75,800	21,000
23	24,400	--	--	--	47,500	800	700	2,300	200	75,900	19,900
24	24,400	--	--	--	47,500	800	700	2,400	200	76,000	18,800
25	24,400	--	--	--	47,500	800	700	2,500	200	76,100	17,700
26	24,400	--	--	--	47,500	800	700	2,500	200	76,100	16,700
27	--	-3,100	-9,900	-1,000	--	--	--	--	--	-14,000	-2,900

Table 22.--Estimate of actual cash flow for selling and advertising expenses

Year (T)	Payroll	Travel expenses	Advertising	Telephone	TOTALS	Present values
0	--	--	--	--	--	--
.5	9,000	2,000	5,000	200	16,200	15,700
1	20,300	8,000	80,000	1,000	109,300	103,100
1.5	20,300	8,000	40,000	1,500	69,800	64,000
2	20,400	8,000	60,000	2,000	90,400	80,500
3	40,700	15,000	80,000	3,300	139,000	116,800
4	40,700	15,000	70,000	3,300	129,000	102,200
5	40,700	15,000	60,000	3,300	119,000	88,900
6	40,700	15,000	50,000	3,300	109,000	76,800
7	40,700	15,000	50,000	3,300	109,000	72,500
8	40,700	15,000	50,000	3,300	109,000	68,300
9	40,700	15,000	50,000	3,300	109,000	64,500
10	40,700	15,000	50,000	3,300	109,000	60,800
11	40,700	15,000	50,000	3,300	109,000	57,400
12	40,700	15,000	50,000	3,300	109,000	54,200
13	40,700	15,000	50,000	3,300	109,000	51,100
14	40,700	15,000	50,000	3,300	109,000	48,200
15	40,700	15,000	50,000	3,300	109,000	45,500
16	40,700	15,000	50,000	3,300	109,000	42,900
17	40,700	15,000	50,000	3,300	109,000	40,500
18	40,700	15,000	50,000	3,300	109,000	38,200
19	40,700	15,000	50,000	3,300	109,000	36,000
20	40,700	15,000	50,000	3,300	109,000	34,000
21	40,700	15,000	50,000	3,300	109,000	32,100
22	40,700	15,000	50,000	3,300	109,000	30,200
23	40,700	15,000	50,000	3,300	109,000	28,500
24	40,700	15,000	50,000	3,300	109,000	26,900
25	40,700	15,000	50,000	3,300	109,000	25,400
26	40,700	15,000	50,000	3,300	109,000	24,000
27	--	--	--	--	35,000	7,300

Table 23 is a summary of the data shown in tables 16 through 22. It shows the total cash flow estimates for each department as well as for the entire plant. The present values of each of these cash flows are also shown. They were computed using a 6 percent rate of interest and equal the sums of the last columns shown in tables 16 through 22 for the respective departments.

The present value for all the costs is $9,526,000. This is $743,000 more than the present value of all estimated sales revenue (table 2). The cost reductions needed to make an FPL paneling plant an attractive investment are therefore quite large.

DEPARTMENTAL AND TOTAL COSTS

Table 24 shows the figures obtained in converting the present values of the expenses for each department to level annual cost figures using the method of computation discussed earlier.

Table 25 shows the average costs of production for both the output from each department and for the final product. The higher costs attributable to the final product are due to the reductions in volume that would occur as the material passes through subsequent manufacturing operations. The department costs shown per square foot of final product apply to all material that would be handled by each department, but the total cost figure of $.241/square foot is the weighted average for 2,500,000 square feet of prefinished paneling and 700,000 square feet of unfinished material per year.

Table 23.--Estimate of actual cash flow for the FPL paneling plant expenses
(Before income tax considerations)

Year (T)	Office and misc. overhead	Sawmill department	Press drying department	Wood-working department	Pre-finishing department	Packaging & warehouse department	Sales & advertising department	Plant Total
0	$ 34,300	$ 5,000	$ 300	$ 1,000	600	$ 3,100	$ 000	$ 44,300
0.5	40,600	33,000	32,800	53,000	20,300	17,000	15,200	212,900
1	65,200	174,100	244,900	200,800	111,900	27,200	109,300	934,400
1.5	42,500	62,500	24,200	50,900	29,800	24,400	69,800	304,100
2	65,100	64,000	27,200	52,800	47,100	37,400	90,400	384,000
3	102,600	126,700	52,900	103,700	92,900	73,900	139,000	691,700
4	102,600	127,400	54,200	104,600	93,400	74,000	129,000	685,200
5	102,600	128,100	55,500	105,500	93,900	74,100	119,000	678,700
6	102,600	128,800	56,800	106,400	94,400	74,200	109,000	672,200
7	102,600	129,500	58,100	107,300	94,900	74,300	109,000	675,700
8	102,600	130,200	59,400	108,200	95,400	74,400	109,000	679,200
9	102,600	130,900	60,700	109,100	95,900	74,500	109,000	682,700
10	102,600	131,600	62,000	110,000	96,400	74,600	109,000	686,200
11	102,600	132,300	63,300	110,900	96,900	74,700	109,000	689,700
12	102,600	133,000	64,600	111,800	97,400	74,800	109,000	693,200
13	102,600	133,700	65,900	112,700	97,900	74,900	109,000	696,700
14	102,600	134,400	67,200	113,600	98,400	75,000	109,000	700,200
15	102,600	135,100	68,500	114,500	98,900	75,100	109,000	703,700
16	102,600	135,800	69,800	115,400	99,400	75,200	109,000	707,200
17	102,600	136,500	71,100	116,300	99,900	75,300	109,000	710,700
18	102,600	137,200	72,400	117,200	100,400	75,400	109,000	714,200
19	102,600	137,900	73,700	118,100	100,900	75,500	109,000	717,700
20	102,600	138,600	75,000	119,000	101,400	75,600	109,000	721,200
21	102,600	139,300	76,300	119,900	101,900	75,700	109,000	724,700
22	102,600	140,000	77,600	120,800	102,400	75,800	109,000	728,200
23	102,600	140,700	78,900	121,700	102,900	75,900	109,000	731,700
24	102,600	141,400	80,200	122,600	103,400	76,000	109,000	735,200
25	102,600	142,100	81,500	123,500	103,900	76,100	109,000	738,700
26	102,600	142,400	82,000	123,800	104,100	76,100	109,000	740,000
27	15,800	-22,500	-8,500	-36,100	-8,200	-14,000	35,000	-38,500
Present value at 6% interest	$1,381,100	$1,794,600	$1,025,900	$1,574,700	$1,279,800	$ 933,400	$1,536,500	$9,526,000

Table 24.--Computation of the level annual costs for the FPL paneling for the estimated 25-year economic life of the plant (T_1 - T_{26})

(Computed at 6 percent before income tax considerations)

Department	Present value of expenses	Pro rata share of overhead expenses	Total V_o	V_1	Level annual costs from T_1 to T_{26}	Less annual costs of accessory products	Level annual costs of FPL paneling
Sawmill	$1,794,600	$ 304,400	$2,099,000	$ 2,224,900	$174,000	$ 14,700	$159,300
Press drying	1,025,900	174,000	1,199,900	1,271,900	99,600	000	99,600
Woodworking	1,574,700	267,100	1,841,800	1,952,300	152,700	4,900	147,800
Prefinishing	1,279,800	217,000	1,496,800	1,586,600	124,100	000	124,100
Packaging and warehouse	933,400	158,100	1,091,500	1,157,000	90,500	000	90,500
Sales and advertising	1,536,500	260,500	1,797,000	1,904,800	149,000	000	149,000
TOTALS	$8,144,900	$1,381,100	$9,526,000	$10,097,500	$789,900	$ 19,600	$770,300

Table 25.--Average costs of production for the FPL paneling

(Computed at 6 percent before income tax considerations)

Department	Level annual costs	Sq. ft. of annual department output	Average cost per sq. ft. of department output	Sq. ft. of annual paneling production	Average cost per sq. ft. of paneling production
Sawmill	$159,300	7,500,000	$0.021	3,200,000	$0.050
Press drying	99,600	7,375,000	0.014	3,200,000	0.031
Woodworking	147,800	3,275,000	0.045	3,200,000	0.046
Prefinishing	124,100	2,500,000	0.050	2,500,000	0.050
Packaging and Warehouse	90,500	3,200,000	0.028	3,200,000	0.028
Sales and Advertising	149,000	3,200,000	0.047	3,200,000	0.047
TOTAL	$770,300			3,200,000	$0.241

Table 26 shows the cost allocated to the prefinished and unfinished paneling. The total average costs being $0.252 and $0.202 per square foot, respectively.

CORPORATION INCOME TAX EFFECTS

Earlier in this report, it was shown that the estimated net present value of an investment in a FPL paneling plant would be -$743,000 when computed at a 6 percent interest rate before income tax considerations. The income tax advantages that would accrue to a large diversified corporation, however, would favorably affect these results. The maximum tax advantages could be obtained by a corporation that already has sufficient net earnings to place it well into the maximum corporation tax bracket of 48 percent.

The following example shows that even for such a firm, a FPL paneling plant does not appear to be an attractive investment. Table 27 shows the net affect the double straight line declining balance depreciation method would have on the net cash flow for each year. The sales revenue figures are the same as those shown in Table 2. The deductible operating expenses are taken from the last column in Table 23, excluding the capital expenditures for land, building, and equipment. The deductible operating expenses from T_o to T_2 are, therefore, lower than the actual cash expenditures shown in Table 23. The deductible expenses in T_{27} are higher than the actual expenses because they include the costs of inventories that would be

Table 26.--Average cost of production for prefinished and unfinished FPL paneling

(Computed at 6 percent before income tax considerations)

Department	Level annual costs for all paneling	Prefinished paneling			Unfinished paneling		
		Level annual costs	Annual production (sq.ft.)	Cost per sq. ft.	Level annual costs	Annual production (sq. ft.)	Cost per sq. ft.
Sawmill	$159,300	$124,500	2,500,000	$0.050	$ 34,800	700,000	$0.050
Drying	99,600	77,800	2,500,000	0.031	21,800	700,000	0.031
Woodworking	147,800	115,500	2,500,000	0.046	32,300	700,000	0.046
Prefinishing	124,100	124,100	2,500,000	0.050	000	000	.000
Packaging and warehouse	90,500	70,700	2,500,000	0.028	19,800	700,000	0.028
Sales and advertising	149,000	116,400	2,500,000	0.047	32,600	700,000	0.047
TOTAL	$770,300	$629,000	2,500,000	$0.252	$141,300		$0.202

Table 27.--Income tax effects on net cash flow for a company in the 48 percent income tax bracket using the double straight line declining balance depreciation method

Year (T)	Sales revenue	Deductible operating expenses	Building depreciation	Equipment depreciation	Total depreciation	Taxable income	Tax effects
0	$ 000	$ 30,000	$ 000	$ 000	$ 000	-$ 30,000	$ 14,400
1	000	136,000	000	000	000	- 136,000	65,300
2	555,000	578,100	19,800	190,700	210,500	- 233,600	112,100
3	740,000	691,700	17,800	152,600	170,400	- 122,100	58,600
4	740,000	685,200	16,000	122,100	138,100	- 83,300	40,000
5	740,000	678,700	14,400	97,600	112,000	- 50,700	24,300
6	740,000	672,200	13,000	78,100	91,100	- 23,300	11,200
7	740,000	675,700	11,700	62,500	74,200	- 9,900	4,800
8	740,000	679,200	10,500	62,500	73,000	- 12,200	5,900
9	740,000	682,700	9,500	62,500	72,000	- 14,700	7,100
10	740,000	686,200	8,500	62,500	71,000	- 17,200	8,300
11	740,000	689,700	7,700	62,500	70,200	- 19,900	9,600
12	740,000	693,200	7,000	000	7,000	39,800	- 19,100
13	740,000	696,700	6,900	000	6,900	36,400	- 17,500
14	740,000	700,200	6,900	000	6,900	32,900	- 15,800
15	740,000	703,700	6,900	000	6,900	29,400	- 14,100
16	740,000	707,200	6,900	000	6,900	25,900	- 12,400
17	740,000	710,700	6,900	000	6,900	22,400	- 10,800
18	740,000	714,200	6,900	000	6,900	18,900	- 9,100
19	740,000	717,700	6,900	000	6,900	15,400	- 7,400
20	740,000	721,200	6,900	000	6,900	11,900	- 5,600
21	740,000	724,700	6,900	000	6,900	8,400	- 4,000
22	740,000	728,200	000	000	000	11,800	- 5,700
23	740,000	731,700	000	000	000	8,300	- 4,000
24	740,000	735,200	000	000	000	4,800	- 2,300
25	740,000	738,700	000	000	000	1,300	- 600
26	740,000	740,000	000	000	000	000	000
27	90,600	167,000	000	000	000	- 76,400	11,200

liquidated during this year. It is further assumed that these inventories would be built up during the first year of plant operation and their costs were not included in the allowable expense deductions for this year.

The depreciation schedules used in Table 27 are 10 and 20 years, respectively, for the equipment and building. The double straight-line declining balance method of depreciation was used until it became advantageous to switch to a straight-line method for the remaining depreciable life of these assets. This occurred in year T_7 for the equipment and year T_{13} for the building.

The tax effects are positive for the years in which taxable income is negative. This is because every dollar of operating losses incurred by the FPL paneling plant according to an acceptable accounting procedure, would reduce the corporation's income tax on other income by $0.48. Conversely, when taxable income is positive, the tax effects are negative.

The tax effects shown in Table 27 for T_{27} include the effects of the capital gains income tax provisions on the estimated $86,000 that would be received from the disposal of the building and equipment. The $43,000 portion of this income subject to income taxes under the capital gains provisions is offset by a $76,400 operating loss making the net taxable income -$23,400. This results in a tax benefit of $11,200 for this year.

Table 28 shows the annual net cash flows after income taxes as well as their individual and total present values. The income

Table 28.--Present value of the net cash flow for a company in the 48 percent income tax bracket using the double straight-line declining balance method and a 6 percent borrowing rate

Year	Sales revenue	Production expenses	Tax effects	Net cash flow	Present value*
0	$ 000	$ 44,300	$ 14,400	-$ 29,900	-$ 29,900
0.5	000	212,900	000	- 212,900	- 209,600
1	000	934,400	65,300	- 869,100	- 843,000
1.5	185,000	304,100	000	- 119,100	- 113,700
2	370,000	384,000	112,100	98,100	92,300
3	740,000	691,700	58,600	106,900	97,500
4	740,000	685,200	40,000	94,800	83,900
5	740,000	678,700	24,300	85,600	73,500
6	740,000	672,200	11,200	79,000	65,800
7	740,000	675,700	4,800	69,100	55,800
8	740,000	679,200	5,900	66,700	52,200
9	740,000	682,700	7,100	64,000	48,600
10	740,000	686,200	8,300	62,100	45,800
11	740,000	689,700	9,600	59,900	42,800
12	740,000	693,200	- 19,100	27,700	19,200
13	740,000	696,700	- 17,500	25,800	17,300
14	740,000	700,200	- 15,800	24,000	15,700
15	740,000	703,700	- 14,100	22,200	14,000
16	740,000	707,200	- 12,400	20,400	12,500
17	740,000	710,700	- 10,800	18,500	11,000
18	740,000	714,200	- 9,100	16,700	9,600
19	740,000	717,700	- 7,400	14,900	8,300
20	740,000	721,200	- 5,600	13,200	7,200
21	740,000	724,700	- 4,000	11,300	6,000
22	740,000	728,200	- 5,700	6,100	3,100
23	740,000	731,700	- 4,000	4,300	2,100
24	740,000	735,200	- 2,300	2,500	1,200
25	740,000	738,700	- 600	700	300
26	740,000	740,000	000	000	000
27	186,000**	57,000	11,200	140,800	61,700
TOTAL					-$348,800

* Computed using 3.1 percent on the effective after-tax rate.
** Includes $90,600 from product sales and $96,000 from liquidated assets

from the liquidation of the land, building and equipment in T_{27} is added to the sales revenue for that year instead of being treated as a negative expense. Since this table is used to show the present value of the net cash flows, it makes no difference which way this income is treated.

The rate used for discounting in Table 28 is 3.1 percent since this would be the effective after-tax rate for a firm that could borrow the entire capital requirement at a 6 percent interest rate. Every dollar spent for interest payments would lower the income taxes by $0.48.

The total after-tax present value figure of -$348,800 shown in Table 28 is a substantial improvement over the -$743,000 figure obtained before income taxes were considered. It still shows, however, that the FPL paneling plant would not be an attractive investment for even a large profitable corporation that could obtain the maximum amount of income tax advantages. The 7 percent investment credit advantage was not included in the above example because it has been suspended. The other two commonly used methods, straight-line and the sum-of-the-year's digits, would result in present values of -$369,100 and -$350,700, respectively.

The possible effect of income taxes on per unit production costs can be obtained by continuing the above example. The present value of all product sales revenue is $12,221,100 when discounted to T_o using the after-tax interest rate of 3.1 percent. This, minus the

net present value of -$348,800 results in a present value of $12,569,900 for all production and selling costs.

This present value, V_o, is converted to V_1 using the formula V_1 = $12,569,900 (1.031) = $12,959,600. This value, V_1, can then be converted to a level annual value for the years T_2 to T_{26} using the formula shown on page 77. This results in a figure of $732,600 per year. When this is divided by the estimated annual FPL paneling production of 3,200,000 square feet, the cost per square foot is $0.2289.

The double straight-line declining balance method was used in the above example because it would be the most advantageous method. The sum-of-the-year's digits and the straight-line depreciation methods would result in per square foot costs of $0.2290 and $0.2293, respectively. While production costs cannot be predicted so precisely, these figures have been carried out to the nearest $0.0001 to show the differences between the three main depreciation methods accepted for federal income tax purposes. All of these figures round off to $0.229 per square foot, which is $0.012 less than the before income tax average cost estimate of $0.241 (Table 25).

These income tax advantages would make the average production cost almost as low as the average f.o.b. sales price of $0.225 per square foot. There would still be no profit incentive, however, for a prospective manufacturer could obtain all these advantages.

APPENDIX

APPENDIX A.

List of Wood-Using Companies Visited During the Study

J. W. Black Lumber Company
Corning, Arkansas

Harris Manufacturing Company
Johnson City, Tennessee

Tibbals Flooring Company
Oneida, Tennessee

Townson Lumber Company
Murphy, North Carolina

Wood-Mosaic Corporation
Louisville, Kentucky

Gamble Brothers, Inc.
Louisville, Kentucky

Poorbaugh Lumber Company
Stoystown, Pennsylvania

Townsend Lumber Company
Stuttgart, Arkansas

West Lumber Company
Atlanta, Georgia

APPENDIX B.

List of Equipment and Material Manufacturers Which Supplied Usable Cost Information and Equipment Specifications

Abrasive Products, Inc.
South Braintree, Massachusetts

Allis Chalmers Manufacturing Co.
Milwaukee, Wisconsin

American Sawmill Machinery Co.
Corinth, Mississippi

Armco Steel Corporation
Middletown, Ohio

Behr-Manning Company
Troy, New York

Bink's Manufacturing Company
Chicago, Illinois

Black Brothers Co, Inc.
Mendota, Illinois

E. W. Buschman Co.
Cincinnati, Ohio

Bush Manufacturing Company
Birmingham, Alabama

Bush Manufacturing Co.
Clawson, Michigan

Buss Machine Works, Inc.
Holland, Michigan

The Carborundum Company
Niagara Falls, New York

Carter Products Company
Grand Rapids, Michigan

Caterpillar Tractor Company
Peoria, Illinois

Clark Equipment Company
Battle Creek, Michigan

The Colson Corporation
Caruthersville, Missouri

Corinth Machinery Company
Corinth, Mississippi

Corley Manufacturing Company
Chattanooga, Tennessee

Cornell Manufacturing Company
Laceyville, Pennsylvania

Danckaert Woodworking Machinery, Co.
Atlanta, Georgia

Dependable Machine Company
Greensboro, North Carolina

The DeVilbiss Company
Toledo, Ohio

Diehl Machines, Inc.
Wabash, Indiana

Dry Clime Lamp Corporation
Greenburg, Indiana

Econotool, Inc.
Huntington Valley, Pennsylvania

Ekstrom, Carlson and Company
Rockford, Illinois

The Fairbanks Company
New York, New York

Fjellman American, Inc.
Joliet, Illinois

Frick Company
Waynesboro, Pennsylvania

Gasway Corporation
Chicago, Illinois

General Corrugated Machinery Company, Inc.
Palisades Park, New Jersey

Gray Company, Inc.
Minneapolis, Minnesota

Greenlee Brothers and Company
Rockford, Illinois

The Hamilton Caster and Manufacturing Company
Hamilton, Ohio

Handy Manufacturing Company
Chicago, Illinois

Hosmer Machine Company
Contoocook, New Hampshire

The Frank G. Hough Company
Libertyville, Illinois

Hyster Company
Danville, Illinois

Irvington Machine Works
Portland, Oregon

Jackson Lumber Harvester Co., Inc.
Mondovi, Wisconsin

Jenkins Woodworking Machinery Co.
Sheboyan Falls, Wisconsin

Karlton Machinery Corporation
Chicago, Illinois

E. Keeler Company
Williamsport, Pennsylvania

The Kirk and Blum Company
Cincinnati, Ohio

George Koch Sons, Inc.
Evansville, Indiana

Lewis-Shepard Products, Inc.
Watertown, Massachusetts

Lilly Industrial Coatings, Inc.
Indianapolis, Indiana

Lineberry Foundry and Machine, Company
North Wilkesboro, North Carolina

R. A. Martin Company
Chicago, Illinois

Mattison Machiney Works
Rockford, Illinois

Mereen-Johnson Machine Co.
Minneapolis, Minnesota

W. F. Meyers Company
Bedford, Indiana

3M Company
Minneapolis, Minnesota

Moore Dry Kilns Company
Jacksonville, Florida

Morbark Debarker Company
Winn, Michigan

Nash-Bell-Challoner
Ashkosh, Wisconsin

Nicholson Manufacturing Company
Seattle, Washington

Nordberg Manufacturing Company
Milwaukee, Wisconsin

Nordson Corporation
Amherst, Ohio

North American Products Corp.
Jasper, Indiana

The Ohio Knife Company
Cincinnati, Ohio

Oliver Machinery Company
Grand Rapids, Michigan

Onsrund Machine Works, Inc.
Niles, Illinois

J. W. Penny & Sons, Co.
Mechanic Falls, Maine

Pettibone Mulliken Corporation
Chicago, Illinois

Phelps Fan Manufacturing Co.
Little Rock, Arkansas

Pistorius Machine Company, Inc.
Hicksville, New York

C. O. Porter Machinery Company
Grand Rapids, Michigan

Powermatic, Inc.
McMinnville, Tennessee

Newman Machine Company
Greensboro, North Carolina

Northfield Foundry and
Machine Company
Northfield, Minnesota

Rees Burner and Blowpipe Company
Memphis, Tennessee

Reliance Universal, Inc.
Louisville, Kentucky

Rodgers Machinery Sales Corp.
Los Angeles, California

Roto Finishing Systems, Inc.
Paramount, California

Ruvo Automation Corporation
Glen Head, New York

St. Regis Paper Company
Attleboro, Massachusetts

Seal-o-matic Dispenser Corp.
Bethlehem, Pennsylvania

Schmutz Manufacturing Company
Louisville, Kentucky

SI Handling Systems, Inc.
Easton, Pennsylvania

Simonds Saw and Steel Co.
Fitchburg, Massachusetts

H. B. Smith Machine Company
Smithville, New Jersey

Soderhamn Machinery Manufacturing
Company
Talladega, Alabama

Southern Abrasives, Inc.
New York, New York

Standard Dry Kiln Company
Indianapolis, Indiana

Stetson-Ross Machine Company, Inc.
Seattle, Washington

Thomas Truck and Caster Co.
Keokuk, Iowa

Timesavers Sanders, Inc.
Minneapolis, Minnesota

Towmotor Corporation
Cleveland, Ohio

Tri-State Machinery Co.
Dallas, Texas

Union Tool Corporation
Warsaw, Indiana

J. A. Vance Company
Winston-Salem, North Carolina

Virginia Machine Tool Company
Bassett, Virginia

Wadkin, Ltd.
Leicester, England

Michael Weinig, KG
Woodworking Machinery Corporation
Valley Stream, New York

West Virginia Pulp and Paper Co.
Richmond, Virginia

B. D. Whitney and Son, Inc.
Greensboro, North Carolina

H. Wiegand Corporation
Yonkers, New York

Wilco Machine Works
Memphis, Tennessee

Williams - White and Co.
Moline, Illinois

Wisconsin Knife Works, Inc.
Beloit, Wisconsin

S. A. Woods Machine Company
Roscoe, Illinois

Yale and Towne, Inc.
Philadelphia, Pennsylvania

P. B. Yates Machine Co.
Hamilton, Ontario, Canada

Yates - American Machine Co.
Roscoe, Illinois